BIRTH ADVANTAGES AND RELATIVE AGE EFFECTS: EXPLORING ORGANISATIONAL STRUCTURES IN YOUTH SPORT

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BIRTH ADVANTAGES AND RELATIVE AGE EFFECTS: EXPLORING ORGANISATIONAL STRUCTURES IN YOUTH SPORT

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EDITORIAL
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Editorial: Birth Advantages and Relative Age Effects

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Editorial on the Research Topic

Birth Advantages and Relative Age Effects: Exploring Organisational Structures in Youth Sport

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We are delighted to have this Research Topic on birth advantages and relative age effects come to fruition. In 2019, the editorial team had several informal conversations about birth advantages and relative age effects in sport. A recurring theme in those discussions was that much of the existing research in the field used archival methods to collect data, and few researchers integrated theory into their studies. As a result, the editorial team met in the autumn of 2019 and formalized our Research Topic for *Frontiers*. Subsequently, we solicited submissions that: (1) focused on birth advantages of any kind, (2) went beyond mining birthdates from registration databases, and (3) were theoretically-driven. Examining the articles included in this Research Topic, we believe these objectives were met, and are incredibly grateful to all of the authors for their strong contributions. The editorial team also made a concerted effort to recruit diverse authors who could support this Research Topic. In doing so, we aimed to highlight varied research approaches, ensuring a unique contribution to the field of birth advantages in sport. The 18 articles that appear in this Research Topic were penned by 65 authors, many of whom are internationally-recognized scholars in this field. These authors represent 35 universities or sport institutions (e.g., professional sport teams or national governing bodies) spanning 13 countries. Owing to our approach, it is not surprising that 16 sports are studied within this Research Topic, with 11 studies including female athletes as participants. Ultimately, we believe that the diverse authorship and samples have resulted in a unique Research Topic, which has significantly advanced the field through its various approaches that should facilitate thoughtful discussion about birth advantages.

In 1983, Paula and Rodger Barnsley first discovered relative age effects in sport as they read a program at an elite amateur ice hockey game that listed all the participating players' birthdates (Barnsley et al., 1985). Understandably then, the first explorations of relative age effects in sport were not a result of applying existing theory to a new setting. For decades, however, birth advantage and relative age effect studies tended to outline these phenomena in various contexts, with little attention paid to understanding and predicting the effects through theory. It was not until 2013 when a theoretical model was proposed to understand relative age effects. The first model was offered by Hancock et al. (2013), which focused on the role social agents (i.e., parents, coaches, and athletes) played in creating and perpetuating relative age effects. Shortly thereafter, Wattie et al. (2015) suggested a constraints-based model (i.e., individual, environment, and task constraints) to explain relative age effects. We believe that grounding research in theory is imperative to advancing this field, which is why we explicitly stated in our call for proposals that the research be theory-driven. Throughout the submission and review process, we encouraged authors to strengthen their theoretical connections. Ultimately, this was successful as the authors of the manuscripts in this Research Topic included theories to support their research. We hope that as this field grows, researchers continue to use existing or new theories to shape their research.

As noted above, birth advantage and relative age effect studies have relied on archival data to show associations between some relatively unchangeable variables (e.g., birthdate, birthplace, handedness, gender, or maturity status) and some outcome measures of achievement (e.g., member of an elite team in sport or performance indicators). In the last few years, more diverse research approaches and methodologies have been used to document the "why" and "how" of the relationship between birth characteristics and athlete development. For example, social relationships have been proposed as a primary mechanism that adjusts the strength of the relationships between birth characteristics and outcomes. Moving forward, it appears that more studies driven by strong theoretical frameworks are needed to provide a better understanding of the mediating mechanisms that affect birth advantages in sport. Additionally, research on birth advantages would benefit from studies based on exploratory research questions such as "When do birth advantages disappear?" and "For whom does age and anthropometric banding work?" The various articles in this Research Topic provide examples of innovative qualitative (e.g., content analysis, composite narratives, and questionnaires) and quantitative approaches (e.g., Bayesian analysis, correlation and regression analysis, and multivariate analysis of covariance) that are starting to be used in birth advantages research. It is our hope that this Research Topic will inspire researchers to move beyond descriptive studies of relative age effects and continue to design new studies with innovative methodologies that will shed light on the "why," "how," "when," and "for whom" of birth advantages in sport.

Our purpose for this Research Topic was to explore the organizational structures in youth sport that contribute to birth advantages and relative age effects. The contributing authors embraced this opportunity, and through their inclusion of a variety of research topics, have advanced our knowledge of various organizational and social structures that influence birth advantages and relative age effects. As an example, although maturity status inevitably interacts with relative age, Doncaster et al. used FC Barcelona as a case study to encourage researchers and stakeholders (i.e., coaches, practitioners, and policy makers) to appreciate factors beyond the physical (e.g., technical, psychological, and perceptual-cognitive attributes) when examining relative age effects. Moreover, Kelly et al. revealed that those born toward the end of the cut-off date were almost four times more likely to achieve senior professional and international levels in English rugby union compared to those born at the beginning of the cut-off date. They suggest that relatively younger players might have a greater likelihood of achieving expertise following entry into a talent pathway due to benefitting from more competitive play against relatively older peers during their development (e.g., the underdog hypothesis; Gibbs et al., 2012). In addition, Smith et al. showed how "confusion reigned" following the change of cut-off dates in 2015 by the US Soccer Federation, demonstrating a possible disconnect between research and youth sport policy with regards to possible solutions for relative age effects, which can lead to unintended consequences for key stakeholders in sport. Overall, it is essential that researchers and stakeholders use this information to develop an awareness of the integrated organizational and social environments that shape relative age and birth advantage effects in sport.

To gain a deeper understanding of birth advantages and relative age effects in sport, it is important to recognize that they often represent a by-product of sport organizations' policies regarding grouping athletes by chronological age (Turnnidge and Kelly, 2021). Although such policies are often intended to promote developmentally appropriate levels of challenge and create more equal competition, it is evident that these policies can have unintended consequences. Indeed, despite their widespread prevalence, there appears to be a paucity of empirical research and practical application of strategies specifically designed to moderate birth advantages and relative age effects [see Webdale et al. (2020) for a review]. Thus, an additional aim of our Research Topic was to encourage submissions that examined contemporary strategies that address birth advantages and relative age effects. As an individual sport example, Kelly et al. offered a new approach named "birthday-banding," whereby athletes move up to their next birthdate group on their birthday, with the aim of removing particular selection time-points and fixed chronological age groups. From a team sport perspective, Helsen et al. proposed "estimated development age" as a new method for grouping young athletes using the midway point of their chronological and developmental birthdates, with the aim of decreasing relative age *and* maturity-related biases. As we navigate our way toward a new era of birth advantage and relative age literature, we encourage researchers and practitioners to work collaboratively to design, implement, and evaluate a range of fresh, theoretically-driven solutions. By doing so, we can help moderate birth advantages and relative age effects while continuing to promote positive participation, performance, and personal development outcomes in youth sport across the immediate, short-, and long-term timescales (Côté et al., 2021).

It was a pleasure to assemble this Research Topic. We hope the reader finds the articles included to be informative, innovative, and inspiring. Thank you to all the contributing authors and reviewers, without whom, this Research Topic would not be possible.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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REFERENCES

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *CAHPER J.* 51, 23–28.

Côté, J., Murata, A., Turnnidge, J., and Hancock, D. J. (2021). "Situating birth advantages within the youth sport system," in *Birth Advantages and Relative Age Effects in Sport: Exploring Organizational Structures and Creating Appropriate Settings,* eds A. Kelly, J. Côté, M. Jeffreys, and J. Turnnidge (London: Routledge), 15–29. doi: 10.4324/9781003163572-4

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. *Int. Rev. Sociol. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Turnnidge, J., and Kelly, A. L. (2021). "Organizational structures: looking back and looking ahead," in *Birth Advantages and Relative Age Effects in Sport: Exploring Organizational Structures and Creating Appropriate Settings,* eds A. L. Kelly, J. Côté, M. Jeffreys, and J. Turnnidge (London: Routledge), 239–246. doi: 10.4324/9781003163572-18

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

Webdale, K., Baker, J., Schorer, J., and Wattie, N. (2020). Solving sport's "relative age" problem: a systematic review of proposed solutions. *Int. Rev. Sport Exerc. Psychol.* 13, 187–204. doi: 10.1080/1750984X.2019.1675083

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The Relative Age Effect and Talent Identification Factors in Youth Volleyball in Poland

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Previous studies in team sports have not reported evidence regarding the relative age effect (RAE) in relation to the talent identification (TI) process in volleyball, which is organized and controlled by a national federation. Volleyball is a non-contact team sport in which a player's physique does not directly affect other players in the game but is considered one of the most critical factors in the TI process. The aims of the present study were (1) to determine the differences in the quarterly distribution of age between Polish youth volleyball players from the Olympic Hopes Tournament (OHT) and the general population, (2) to investigate the quarterly differences in anthropometric characteristics and motor test results in OHT participants, and (3) to identify the criteria that determine selection for the National Volleyball Development Program (NVDP). The present study identified the RAE in young male (n = 2,528) and female (n = 2,441) Polish volleyball players between 14 and 15 years of age who competed in the elite OHT in 2004–2015. The study included anthropometric characteristics, motor test results, and selection for the NVDP. The multivariate analysis of covariance demonstrated no significant main effect for birth quarter or calendar age in any of the OHT female players or in male players selected for the NVDP. In the group of non-selected NVDP male players, the analysis demonstrated significant differences by birth quarter as a covariate for body height (F = 0.01, p < 0.001), spike reach (F = 7.33, p < 0.05), and block jump (F = 0.02, p < 0.001). Significant differences by calendar age as a covariate were observed for body mass (F = 0.53, p < 0.01), spike jump (F = 2.64, p < 0.05), block jump (F = 0.4, p < 0.01), and zigzag agility test results (F = 0.01, p < 0.01). The results showed a significant overrepresentation of early-born participants in the OHT and NVDP subsamples. The classification model demonstrated that a combination of four characteristics optimally discriminated between players selected for the NVDP and those who were not selected. This combination of variables correctly classified 77.7% of the female players and 71.8% of the male players in terms of their selection for the NVDP. The results of this study show that jumping ability and body height are crucial in the TI and selection process in youth volleyball.

Keywords: selection, youth development, calendar age, maturity, sports success

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INTRODUCTION

The requirements of youth sports lead to the age banding of players into training groups and teams; sports administrators age-band players into training groups relative to cutoff dates (e.g., the start and end of the calendar year; Cobley et al., 2009). The assessment of players by trainers during the talent identification (TI) process can be disrupted by differences in the players' biological development (Ramos et al., 2019) and sociological factors (Hancock et al., 2013). Players born closer to the starting point of their age group relative to their peers may be older by as much as 2 to 5 years (Johnson et al., 2017), and the selection of more mature and stronger players will result in an overrepresentation of players born in the first part of the selection period (e.g., quarter). As a consequence, in youth ball sports, later-born and less mature players are strongly underrepresented, especially at the elite level (Hill and Sotiriadou, 2016). This phenomenon is a well-documented selection bias and is known as the relative age effect (RAE; Musch and Grondin, 2001).

The presence of an RAE has been observed at the senior and youth levels in the following contact team sports: basketball (Arrieta et al., 2016; Werneck et al., 2016), soccer (González-Víllora et al., 2015; Skorski et al., 2016), and handball (Schorer et al., 2009). Contrary, the RAE was not found in other team sports such as rugby (Jones et al., 2018) and water polo (Barrenetxea-Garcia et al., 2018). In line with this, the findings of existing literature on RAE in contact team sports have been controversial so far. Nevertheless, it is reported that discrimination against players born in the last quarter of a calendar year differs, depending on the position, gender, age of the player (Salinero et al., 2013; Lidor et al., 2014), and expertise level (Praxedes et al., 2017). Volleyball, however, is a non-contact team sport in which a player's physique does not directly affect other players in the game. It was reported that more than two-thirds of all points scored in volleyball are due to short dynamic bouts that mainly depend on players' vertical jump and body height (Silva et al., 2014). Interestingly, only a few works have considered RAE in terms of birth-date discrimination in volleyball. An overrepresentation of players born in the first quarter of the year compared to other quarters was observed in a group of young male and female players and in the players in the age group younger than 19 years to younger than 23 years in men's World Volleyball Championship (Okazaki et al., 2011; Nakata and Sakamoto, 2012; Campos et al., 2016). In addition, the RAE in volleyball has been identified in school competitions (Reed et al., 2017). Research by Lupo et al. (2019) emphasizes the different nature of the RAE in volleyball compared to other elite team sports in Italy.

Considering the aforementioned, it is clear that RAE manifests itself in such team games according to the physical characteristics of the player. Previous studies about the potential advantage in the physical and motor abilities of early-born players to their counterparts were carried out mostly in the field of other team sports. For example, in youth soccer, possible differences in biological maturation and anaerobic characteristics were observed between players born in the first and fourth quarters of the year (Deprez et al., 2013). Nevertheless, a pilot study from Papadopoulou et al. (2019) shows no quarter differences in anthropometric and physiological characteristics in youth volleyball female players. In contrast, late-born youth basketball players have a "double disadvantage" in body height compared to their peers (Rubajczyk et al., 2017). In addition, advanced maturity status and being relatively older affected players' game-related specific fitness (Duarte et al., 2019). However, the RAE has not been thoroughly explored in volleyball, especially with regard to the TI process.

The TI process in volleyball may be challenging for practitioners. In general, successful discrimination between talented and untalented-identified junior volleyball players is multidimensional and is based on the assessment of skill attributes, a tactical understanding of the game (Jager and Schollhorn, 2007), or game intelligence (Rikberg and Raudsepp, 2011), perceptual-cognitive skills (Alves et al., 2013), motor abilities, and anthropometric and physical characteristics (Marcelino et al., 2014). Despite this, body height is considered a key criterion in the TI process used to assess youth players (Aouadi et al., 2012; Carvalho et al., 2020). Thus, the failure to estimate the adult body height of an athlete will significantly hinder the effective TI process in volleyball (Baxter-Jones et al., 2020). In addition, maturity-associated variation in performance (Sandercock et al., 2013), and sex differences in the onset of puberty (Malina, 2014; Kwieciński et al., 2018) may indicate an ineffective TI process and maintain the existence of the RAE phenomenon in youth sports. Furthermore, in a non-contact team sport such as volleyball, earlier age at the start of peak height velocity and player body height may not be important performance factors but can be decisive factors in TI.

An example of the TI process in volleyball, which is organized and controlled by a national federation, is the Olympic Hopes Tournament (OHT). The OHT, which was first organized in 2004, exemplifies the difficulty of identifying talent in the pool of youth players. This event is organized by the Polish Volleyball Federation (PVF) for elite 14-year-old (born in the corresponding calendar year) Polish male and female players. Tournament participants represent 16 Polish voivodeships and are previously selected via regional PVF divisions. Unfortunately, players' data from their regional PVF clubs before selection for OHTs are not available. Eight of the 12 players who qualify for the OHT from each voivodeship are obligated to meet the minimum body height requirements: 185 cm for male players and 175 cm for female players. All teams play three matches at the group stage and one or more matches in the knockout phase. The PVF sets the net height at 243 cm for boys and 223 cm for girls. During the tournament, experienced PVF coaches assess the players separately by gender and identify the players who will be offered full-time scholarships by the National Volleyball Development Program (NVDP). The final result of the tournament is the selection of male and female players for the NVDP. To the best of our knowledge, there are no reports related to the determination of the RAE or TI factors in youth volleyball tournaments similar in scale to the OHT.

Therefore, the aims of the present study were (1) to determine the differences in the quarterly age distribution between Polish youth volleyball players in the OHT and the general population, (2) to investigate the quarterly differences in anthropometric characteristics and motor test results in OHT participants and (3) to identify the criteria that determine selection for the NVDP. We hypothesized that the players selected for the NVDP would exhibit a taller body height and higher jumping ability than the unselected players would. We also hypothesized that the RAE would be most apparent in the group of males and females selected for the NVDP because of the significant role of player height in volleyball.

MATERIALS AND METHODS

Data Collection

This study included 2,528 male (aged 14.51 ± 0.32 years) and 2,441 female (aged 14.48 ± 0.31 years) players who participated in the OHT in 2004–2015 and were selected from the official database of the PVF. The obtained data were date of birth, anthropometric characteristics, and the results of fitness tests. Data on differences in the quarterly distribution of birth dates in the Polish population (PP) were obtained from the Central Statistical Office. These data corresponded to the birth dates of the players who participated in the OHT (1989–2001). In the PP, there was no significant difference in the shape of the relative quarterly distribution of age among the studied years. All data were obtained according to the Data Protection Act in Poland, and all procedures were approved by the Research Ethics Committee of the University School of Physical Education in Wrocław.

Procedures

To determine the quarterly birth distribution, birth-date data were listed according to the four quarters of the calendar year: Q1 (January–March), Q2 (April–June), Q3 (July–September), and Q4 (October–December). The birth dates of the male and female populations in Poland between 1989 and 2004, which correspond to the birth dates of the players participating in the OHT, were similarly arranged. The OHT competition lasted 3 days: day 1—data collection, anthropometric measurements, and motor tests; day 2—group stage and quarter-final matches; and day 3—semifinal and final matches. The day after the final OHT match, a list of players nominated for the NDVP was published.

All anthropometric and fitness data were obtained by PVF employees in preparation for performing the measurements. In the 12 tournaments from which the results were obtained, the measurements carried out by PVF employees were supervised by the same person. Before the beginning of the tests, a standardized warm-up was carried out. All measurements were taken under the same external conditions in a sports hall and at a similar time of year (October or November). For the anthropometric measurements, the players wore only shorts, and for the performance tests and jumps, they wore shorts, *t*-shirts, and volleyball-specific shoes. All testing conditions were standardized for all measurement points, including test order, hydration, and preassessment food intake.

Anthropometric Characteristics

An electronic scale (kg) and a stadiometer (cm) were used for the anthropometric measurements. Standing reach stature was measured to the nearest centimeter using a yardstick vertical jump device (VolleySystem, Poland). Players were asked to stand with their feet flat on the ground, to extend their arms and hands and to mark their standing reach. Two measurements were made, corresponding to one- and two-arm standing reaches. The intraclass correlation coefficient for test–retest reliability and technical error of measurement (test–retest period of 1 h) in 30 youth male players was 0.24 ($p < 0.01$), which corresponded to 0.1 kg for body weight, 0.83 ($p < 0.01$), and 0.1 cm for body height and 1.18 and 1 cm for standing reach.

Vertical Jump and Block Reach

Vertical jump height was calculated as the highest point reached during a countermovement jump with an arm swing from a standing position. Block reach was measured to the nearest centimeter, and the best value obtained from three trials of countermovement jumps with arm swings was used for the analysis for male and female players, respectively. The players were then instructed to stand on a mark and to leap as high as possible with both legs, displacing as many vanes on the yardstick as possible. All jumps were performed using a yardstick vertical jump device (VolleySystem, Poland). The intraclass correlation coefficient for test–retest reliability (test–retest period of 1 h) in 30 youth male players was 1.97 ($p < 0.01$) for vertical jump and 0.64 for block reach ($p < 0.01$). The technical error of measurement was 1 cm.

Spike Reach and Spike Jump

The players were asked to stand with their feet flat on the ground, extend their arms and hands, and mark their standing reach. They were then instructed to take a run-up or spike approach and to leap as high as possible with both legs, displacing as many vanes on the yardstick as possible (VolleySystem, Poland). A 5-min break between jumps was applied. The best result out of two trials was recorded. The spike jump values were calculated as the difference between the heights of the jump and the standing one-arm reach. The intraclass correlation coefficient for test–retest reliability (test–retest period of 1 h) in 30 youth male players was 0.66 for spike reach ($p < 0.01$). The technical error of measurement was 1 cm.

Zigzag Agility Test

The zigzag agility test consisted of running at maximal speed through a 7 × 7-m zigzag course (**Figure 1**). Timing began with a sound signal and stopped when the subject passed through a timing gate (SECTRO Timing System, Jelenia Gora, Poland); the time was measured in hundreds of seconds. A 5-min break between trials was applied. The best result out of two trials was recorded. The intraclass correlation coefficient for test–retest reliability (test–retest period of 1 h) in 30 youth male players was 0.46 s for the zigzag agility test ($p < 0.01$). The technical error of measurement was 0.01 s.

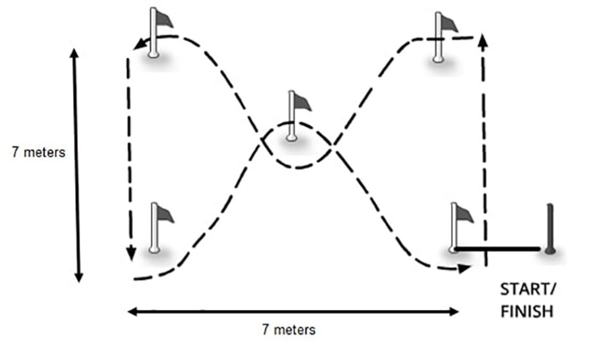

FIGURE 1 | Zigzag agility test.

Statistical Analysis

Assessment of the normality of the variable distributions was performed using the Kolmogorov-Smirnov test with Lilliefors correction. Homogeneity of variance was checked, and no violations were found. The χ^2 test was used to determine the differences between the observed and expected frequencies of a birth-date quartile. The effect size was defined by calculating Cramér's V. The threshold values for V were set according to Cohen's (1988) guidelines for $df = 3$, as follows: ≥ 0.06 (small), ≥ 0.16 (medium), and > 0.29 (large). An independent-samples t test was conducted to determine the differences in anthropometric characteristics and fitness test results between selected and unselected players for each birth quarter. In addition, multivariate analysis of covariance (MANCOVA) with chronological age and age as covariates and anthropometric characteristics and motor test results as dependent variables was used to examine differences among birth quarters (independent variable). A significant α was set at 0.05. Threshold values for effect size statistics were 0.01, 0.06, and 0.14 for small, medium, and large effect sizes, respectively (Cohen, 1988). To support univariate analyses, Bonferroni *post hoc* test was used where appropriate.

Performance characteristics were analyzed using a stepwise discriminant function analysis to determine which combination of the measured characteristics optimally explained the selection of qualifying players to join the NVDP. In this analysis, the group (selected for the NVDP vs. not selected) was the dependent variable, and performance characteristics, birth quarter, and calendar age were the independent variables. The calculation included the cases for which complete data were provided. The analysis did not include the medicine ball throw because of its exclusion from the battery of tests in 2012. All calculations were performed using IBM SPSS statistical software (version 22.0, Armonk, NY, United States).

RESULTS

Table 1 shows the χ^2 test results ($\chi^2 = 7.9$, $p < 0.05$, $V = 0.06$, a small effect for males; $\chi^2 = 1.2$, $p > 0.05$, $V = 0.05$, no effect for females), percentage deviations, and standardized residuals for the comparison of the OHT players and the players selected for the NVDP. The observed quarterly distributions of players selected and not selected for the NVDP were significantly different from the uniform distribution ($p \leq 0.001$). Furthermore, an overrepresentation of young volleyball players born in Q1 and Q2 was reported for both genders. In contrast, an underrepresentation of players born in Q3 and Q4 was observed. In addition, only 6.03% of male players and 11.42% of female players selected for the NVDP were born in the last 3 months of the year. A medium effect size of the RAE was observed in each of the subsamples of volleyball players.

Anthropometric characteristics and results of the zigzag agility test across the four birth quarters or calendar age for each subgroup are shown in **Table 2**. The MANCOVA analysis demonstrated no significant main effect for birth quarter or calendar age in all OHT female players and in male players selected for NVDP. In the group of non-selected male players, the analysis demonstrated significant differences according to the quarter of birth for body height ($F = 0.01$, $p < 0.001$), spike reach ($F = 7.33$, $p < 0.05$), and block jump ($F = 0.02$, $p < 0.001$). Significant differences within calendar age were observed for body mass ($F = 0.53$, $p < 0.01$), spike jump ($F = 2.64$, $p < 0.05$), block jump ($F = 0.4$, $p < 0.01$), and zigzag agility test results ($F = 0.01$, $p < 0.01$). In addition, **Table 2** shows the differences between the selected and unselected players according to birth quarter. Significant differences were found for all anthropometric variables in both genders. The selected NVDP players were taller (all p values < 0.001) and heavier (values from < 0.05 to < 0.001) and jumped higher (values from < 0.05 to < 0.001) than the unselected players. Regarding the mean time obtained in the volleyball agility test, the analyzed groups did not significantly differ in each birth quarter.

The stepwise discriminant analysis results are presented in **Tables 3**, **4**. The model determined that a combination of four characteristics optimally discriminated between the players selected and not selected for the NVDP for each gender. Vertical jump (for females = 0.82, for males = 0.87), body height (for females = 0.8, for males = 0.85), and body mass (for females = 0.8, for males = 0.84) were included in both models. Spike reach (0.84) and spike jump (0.81) were the fourth variables in the male and female models, respectively. This combination of variables correctly classified 77.7% of the female players and 71.6% of the male players in terms of their selection versus non-selection for the NVDP (**Table 5**).

DISCUSSION

This study confirms the presence of an RAE in young Polish volleyball players who participate in the OHT as part of a controlled and organized TI process carried out by the national federation. As predicted, a skewed quarterly age distribution was observed in the groups selected and not selected for the NVDP. Contrary to what was hypothesized, a similar effect size of the RAE was observed regardless of whether the players were selected for the NVDP. A significant difference between the observed and

TABLE 1 | Analysis of birth-date distribution by quarter of the year among Polish elite youth volleyball players.

	Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	Total	χ^2	*p*	*df*	*V*	Effect
Players not selected for the NVDP										
Male	818 (43.08)	532 (28.02)	328 (17.29)	220 (11.61)	1,898	285.1	<0.0001	3	0.25	Medium
Female	745 (39.98)	566 (30.39)	317 (17.01)	235 (12.62)	1,863	158.4	<0.0001	3	0.21	Medium
Players selected for the NVDP										
Male	135 (42.86)	91 (28.89)	70 (22.22)	19 (6.03)	315	46.5	<0.0001	3	0.27	Medium
Female	107 (37.02)	88 (30.45)	61 (21.11)	33 (11.42)	289	23.9	<0.001	3	0.19	Medium
Polish population born in 1989–2001										
Male	779,527 (25.54)	783,084 (25.65)	792,715 (25.97)	697,344 (22.84)	3,052,670	35,957.7	<0.0001	3	0.02	–
Female	739,516 (25.56)	736,556 (25.46)	757,265 (26.17)	659,867 (22.81)	2,893,204	3,988.4	<0.0001	3	0.03	–
OHT players vs. players selected for the NDVP Percentage deviations and standardized residuals										
Male	+0.03% −0.09	+1.8% +0.17	−19.5% +1.49	−38.8% −2.16	2,213	7.9	<0.05	3	0.06	Small
Female	−3.2% −0.33	–	+8.9% +0.67	−4.3% −0.26	2,152	1.2	>0.05	3	0.05	–

χ^2_3, χ^2 test value; p, probability value; and V, Cramér's V.

expected frequencies of birth dates among the players selected for the NVDP compared to the OHT sample was observed. Additionally, the results showed that there were differences in quarterly comparisons between selected and non-selected NDVP players. Nevertheless, the multivariate analysis showed no main effects for females and selected NVDP male players. Moreover, the discriminant analysis identified the factors affecting the TI process in a group of 15-year-old volleyball players.

The identification of the RAE in Polish youth volleyball is consistent with the results of other researchers (Okazaki et al., 2011; Campos et al., 2016). However, the unexpected overrepresentation of early-born male players selected for the NVDP may be explained by gender differences in biological development and the onset of puberty (Schorer et al., 2009; Baptista et al., 2016). In 15-year-old adolescents, sex differences at puberty are significant and persist for up to 1 year in relation to age at the start of peak height velocity (Koziel and Malina, 2018). In line with this, the tests and measurements used by the PVF for the TI process seem to apply to groups of players at significantly different stages of biological development. In addition, the two-stage selection process (call-ups to voivodeship teams and selection for the NVDP after the OHT) may affect the magnitude of the RAE in Polish youth volleyball. Unfortunately, one limitation of this study is the lack of documentation regarding preselection by regional clubs and PVF coaches. On the other hand, the results of this study showed a different pattern in youth OHT participants compared to the previous studies reporting the absence of RAE in international volleyball. The equal quarter-birth distribution was reported in the highest senior level in Dutch volleyball (van Rossum, 2006) and Israeli and in female Israeli (Lidor et al., 2014) and Brazilian volleyball (Parma and Penna, 2018). Nevertheless, in a similar context, only in a research carried out by Papadopoulou et al. (2019) did the participants' age corresponded with data obtained in this study, but that study was conducted with small samples (clubs from one city). The effect size of RAE reported in this study was equal in each group, but there was a trend of stronger discrimination against late-born male ball-game players.

The unexpected overrepresentation of early-born male players among those selected for the NVDP not only arises from physical development but also may be due to the differences in game demands between male and female volleyball. Previous studies have shown significant gender differences in volleyball game–related statistics (Joao et al., 2010; Nikolaidis et al., 2015). Men's volleyball is characterized by a strength-based style of play, in contrast with the more technical nature of women's games. A study by Pion et al. (2015) reported that motor coordination differentiates elite Belgian female players from sub-elite players. This argument is further supported by the results of Vargas et al. (2018), which indicated that players could achieve success in women's volleyball even if their physical characteristics were different from those typical of male players (e.g., lower body height).

Interestingly, the differences in anthropometric characteristics and motor test results related to the quarter in which a player was born were observed only in players who were not selected to the NDVP. However, quarter-by-quarter comparisons of the mean anthropometric variables of selected and non-selected showed differences among the female players. These findings are supported by a recent study by Carvalho et al. (2020) comparing the morphological profiles of Portuguese adult female players at different levels. They suggest that "higher body mass, body height... are important for top-level performance...," which is in line with research indicating that body height and spike jump reach are the decisive factors for the selection of junior national female volleyball players (Tsoukos et al., 2019). Conversely, previous studies have shown that anthropometric data are inefficient for discriminating between successful and unsuccessful talent-identified junior volleyball players (Gabbett et al., 2007). Note that the discriminant analysis in the present study was conducted with a decidedly larger sample.

The results of the abovementioned studies show that jumping ability, body height, and body mass are crucial for selection for the NVDP regardless of gender. This is consistent with reports showing that a high block jump characterizes the best male volleyball players (Sattler et al., 2015). However, the discriminative models presented in this

TABLE 2 | Anthropometric variables and motor test results for Polish youth volleyball players across four birth quarters.

	Q1	Q2	Q3	Q4	Covariates			
Male—non-selected to NDVP	***n* = 818**	***n* = 532**	***n* = 328**	***n* = 220**	**F (CA)**	***p***	**F (Q)**	***p***
CA	14.78 ± 0.1	14.49 ± 0.1	14.31 ± 1	14. ± 0.1	—	—	—	—
Body height (cm)	187.5 ± 5.8†	187.1 ± 5.7†	187.6 ± 6†	186.9 ± 6.2†	3.92	n.s.	0.01	***
Body mass (kg)	74.6 ± 8.8$^{\&}$	73.8 ± 8.4†	73.9 ± 9$^{\&}$	72.5 ± 8.7$^{\#}$	0.53	**	5.03	n.s.
Standing one-hand reach (cm)	246.1 ± 8.1†	245.8 ± 7.9†	246.1 ± 8.6†	245.5 ± 8.2†	36.82	n.s.	15.16	n.s.
Spike reach (cm)	315.4 ± 1†	315.0 ± 9.5†	315.0 ± 9.8†	314.3 ± 9.8†	66.12	n.s.	7.33	*
Spike jump (cm)	69.3 ± 8$^{\&}$	69.2 ± 7.9$^{\&}$	69.7.90 ± †	68.8 ± 7.5	2.64	*	1.75	n.s.
Standing two-hand reach (cm)	242.4 ± 7.8†	242.3 ± 8.1†	242.38 ± 8.5†	241.9 ± 8.3$^{\#}$	35.77	n.s.	4.97	n.s.
Block reach (cm)	294.5 ± 8.3†	294.1 ± 8.6†	293.9 ± 9.4†	293.4 ± 9.3$^{\#}$	32.83	n.s.	34.68	n.s.
Block jump (cm)	51.9 ± 6.6$^{\#}$	51.6 ± 6.8†	51.7 ± 6.8	51.6 ± 7.2	0.40	**	0.02	***
Volleyball Agility test (s)	14.8 ± 0.8	14.9 ± 0.8	14.9 ± 0.8	14.9 ± 0.8	0.01	**	0.15	n.s.
Male—selected to NDVP	***n* = 135**	***n* = 91**	***n* = 70**	***n* = 19**				
CA	14.81 ± 0.1	14.51 ± 0.1	14.32 ± 0.1	14.1 ± 0.1	—	—	—	—
Body height (cm)	193.8 ± 5.1	193.3 ± 4.9	193.8 ± 5.6	193.2 ± 6.4	0.00	n.s.	0.56	n.s.
Body mass (kg)	77.1 ± 6.8	77.8 ± 7.7	76.9 ± 7.0	77.0 ± 7.3	0.86	n.s.	1.47	n.s.
Standing one-hand reach (cm)	254.4 ± 7.2	254.2 ± 6.9	254.1 ± 8.2	253.8 ± 9.6	0.48	n.s.	1.90	n.s.
Spike reach (cm)	326.3 ± 8.7	326.6 ± 8.5	326.8 ± 9.2	322.1 ± 7.3	0.03	n.s.	2.42	n.s.
Spike jump (cm)	71.9 ± 8.5	72.4 ± 8	72.6 ± 7.4	68.3 ± 9.6	0.21	n.s.	0.16	n.s.
Standing two-hand reach (cm)	250.7 ± 7.3	250.1 ± 6.6	250.4 ± 7.9	248.2 ± 9.4	0.24	n.s.	1.29	n.s.
Block reach (cm)	304.1 ±	303.2 ± 7.3	303.5 ± 7.6	300.6 ± 9.6	0.16	n.s.	0.66	n.s.
Block jump (cm)	53.4 ±	53.1 ± 5.7	53.1 ± 5.9	52.4 ± 6.4	0.01	n.s.	0.13	n.s.
Volleyball Agility test (s)	14.7 ±	14.9 ± 0.9	14.7 ± 0.8	14.9 ± 0.9	1.63	n.s.	3.39	n.s.
Female—non-selected to NDVP	***n* = 745**	***n* = 556**	***n* = 317**	***n* = 235**	**F(CA)**	***p***	**F(Q)**	***p***
CA (years)	14.78 ± 0.1	14.51 ± 0.1	14.31 ± 0.1	14.1 ± 0.1	—	—	—	—
Body height (cm)	174.7 ± 5.4†	174.7 ± 5.6†	175.2 ± 5.4†	174.5 ± 5.6†	0.04	n.s.	0.46	n.s.
Body mass (kg)	62.5 ± 7.9	62.5 ± 8	62.2 ± 7.7	61.5 ± 8.1$^{\#}$	0.00	n.s.	0.84	n.s.
Standing one-hand reach (cm)	227.9 ± 7.9†	227.7 ± 8†	228.5 ± 8†	227.3 ± 8.2†	0.02	n.s.	0.24	n.s.
Spike reach (cm)	277.3 ± 8.4†	277.6 ± 8.6†	277.4 ± 8†	276.8 ± 8.9†	0.36	n.s.	1.05	n.s.
Spike jump (cm)	49.3 ± 6.5	49.8 ± 6.8$^{\&}$	49.0 ± 6.1†	49.5 ± 6.8$^{\#}$	0.90	n.s.	0.56	n.s.
Standing two-hand reach (cm)	222.2 ± 25.9	222.5 ± 23.7	225.7 ± 7.8	223.4 ± 18.4$^{\&}$	0.10	n.s.	0.32	n.s.
Block reach (cm)	260.4 ± 29.2†	260.8 ± 26.7	264.1 ± 7.3	261.4 ± 19†	0.24	n.s.	0.58	n.s.
Block jump (cm)	38.5 ± 5.3	38.6 ± 5.7†	38.4 ± 4.9	38.0 ± 5.2$^{\&}$	0.72	n.s.	1.40	n.s.
Volleyball Agility test (s)	16.2 ± 1.1	16.1 ± 1	16.2 ± 1	16.3 ± 1.1	0.12	n.s.	0.94	n.s.
Female—selected to NDVP	***n* = 107**	***n* = 88**	***n* = 61**	***n* = 33**				
CA	14.83 ± 0.1	14.52 ± 0.1	14.29 ± 0.1	14 ± 0.1	—	—	—	—
Body height (cm)	180.9 ± 5.2	179.5 ± 4.9	180.2 ± 4.9	182.4 ± 4.5	0.62	n.s.	5.13	n.s.
Body mass (kg)	65.1 ± 7.8	63.3 ± 6.9	62.8 ± 8.6	65.3 ± 7.5	0.01	n.s.	0.14	n.s.
Standing one-hand reach (cm)	235.8 ± 7.5	234.3 ± 7.1	235.4 ± 6.9	238.3 ± 9.3	0.91	n.s.	1.43	n.s.
Spike reach (cm)	288.9 ± 7.6	286.9 ± 7.8	287.6 ± 7.1	291.0 ± 8.2	0.89	n.s.	2.01	n.s.
Spike jump (cm)	53.1 ± 6.9	52.6 ± 6.7	52.3 ± 7.4	52.7 ± 7.1	0.00	n.s.	0.09	n.s.
Standing two-hand reach (cm)	229.9 ± 26.8	228.6 ± 28	223 ± 48.5	234.0 ± 4.9	2.14	n.s.	1.31	n.s.
Block reach (cm)	270.2 ± 31	269.6 ± 32.8	261.4 ± 56.7	275.0 ± 5.2	1.88	n.s.	1.06	n.s.
Block jump (cm)	41.0 ± 5.3	41.7 ± 5.6	39.8 ± 5.6	41.1 ± 5.2	0.11	n.s.	0.23	n.s.
Volleyball Agility test (s)	16.0 ± 0.9	16.1 ± 1	16.1 ± 1	16.2 ± 0.9	0.38	n.s.	0.02	n.s.

$^{\#}p < 0.05$, $^{\&}p < 0.01$, and $^{\dagger}p < 0.001$ *in independent paired t tests.*

study were limited and correctly classified 77.7% of female and only 71.8% of male volleyball players according to their selection or non-selection to the NVDP. This is in contrast to the handball study conducted by Mohamed et al. (2009), which reported a correct classification rate of 87.2%. Notably, that study and other previously mentioned studies obtained simple anthropometric measurements without performing a detailed body composition analysis (i.e., fat

TABLE 3 | Stepwise discriminant analysis of included variables—females.

Step	Entered	Lambda	df1	df2	df3	Exact *F*			
						Statistic	*df*1	*df*2	*P* value
1	Vertical jump	0.82	1	1	1,566	309	1	1,566	<0.001
2	Spike jump	0.81	2	1	1,556	162	2	1,565	<0.001
3	Body height	0.8	3	1	1,556	124	3	1,564	<0.001
4	Body mass	0.8	4	1	1,556	98	4	1,563	<0.001

At each step, the variable that minimizes the overall Wilks' lambda is entered. The maximum number of steps is 20; the minimum partial F for inclusion is 3.84; the maximum partial F for removal is 2.71; and the F level, tolerance, or VIN is insufficient for further computation.

TABLE 4 | Stepwise discriminant analysis of included variables—males.

Step	Entered	Lambda	*df1*	*df2*	*df3*	Exact *F*			
						Statistic	df1	df2	*P* value
1	Vertical jump	0.87	1	1	1,644	244	1	1,644	<0.001
2	Body height	0.85	2	1	1,644	141	2	1,643	<0.001
3	Spike reach	0.84	3	1	1,644	102	3	1,642	<0.001
4	Body mass	0.84	4	1	1,644	79	4	1,641	<0.001

At each step, the variable that minimizes the overall Wilks' lambda is entered. The maximum number of steps is 20; the minimum partial F for inclusion is 3.84; the maximum partial F for removal is 2.71; and the F level, tolerance, or VIN is insufficient for further computation.

TABLE 5 | Classification of the stepwise discriminant function analysis (*n* and %).

		Selected for the NDVP	Predicted classification		Total
			Selected	Unselected	
Female[a]	*n*	No	1,083	331	1,414
		Yes	37	199	236
	Correct %	No	76.6	23.4	100
		Yes	15.7	84.3	100
Male[b]	*n*	No	1,026	433	1,459
		Yes	51	208	259
	Correct %	No	70.3	29.7	100
		Yes	19.7	80.3	100

[a]77.7% of the original groupings were correctly classified; [b]71.8% of the original groupings were correctly classified.

free mass), which may indicate significant errors in the predictability and efficiency of the TI process in adolescents, in whom relative body weight seems to be more important (Chung, 2015).

Some aspects of the present study need to be put into perspective. One limitation of this study is the closed settings of the zigzag agility test that was used, which may not directly respond to game-related demands of volleyball. A player who changes direction quickly and efficiently is not necessarily effective in the game, for example, in his/her reaction to a ball flying at high speed (Young, 2015). However, as in previous studies, there was no significant difference between selected and unselected players in test results based on planned change-of-direction (Gabbett et al., 2007; Tsoukos et al., 2019). Our findings support this thesis, and no significant difference in zigzag agility test results was reported between selected and non-selected players. Nevertheless, the ability to change direction efficiently may be a factor for TI in female volleyball players, but only in relation to open tasks and decisive processes (Balser et al., 2014). We suggest including open-skilled agility tests in national federation and club TI processes for youth volleyball.

It is worth highlighting that the strength of the study was the use of a representative large data sample taken from the whole country over 14 years. However, in this study, it was impossible to consider quantified assessments of the volleyball skills of the OHT players because of the lack of documentation by the PVF. Another limitation of this study is the lack of data regarding the players' positions on the court. In this case, such a difference may be caused by the earlier discrimination of relatively later-born players who can play in youth volleyball only as defensive players. A previous study reported differences in somatotypes between setters and centers in elite adult volleyball players (Duncan et al., 2006; Giannopoulos et al., 2017). In line with this, future studies about the TI process in youth volleyball using similar sample sizes should include players' positions on the court.

Considering the findings and limitations of this study, several practical implications can be drawn for policymakers and trainers in the context of the TI process and the RAE in youth volleyball. First, we suggest a rethinking of the TI model in youth volleyball to account for the complexity of the RAE phenomenon and gender differences. It seems unreasonable to adopt the same criteria for assessing groups at different stages of biological development. Second, national federations and clubs should attach greater importance to the consistent collection of information from the TI process. Third, open-skilled agility tests tend to have more value in identifying talented players than tests based only on change of direction.

CONCLUSION

The results of these studies confirm the existence of an RAE in youth volleyball and highlight a trend in the selection of male athletes with greater body weight and height and better jumping ability than their unselected counterpoints. We suggest that TI process in youth volleyball be designed based on complexity of the RAE phenomenon and gender differences in maturity and different anthropometric and motor demands for each player's position on the court.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/supplementary material.

ETHICS STATEMENT

All data were obtained according to the Data Protection Act in Poland, and all procedures were approved by the Research Ethics Committee of the University School of Physical Education in Wrocław. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KR: Conceptualization, investigation, and writing original draft. AR: Formal analysis. KR and AR: Funding acquisition, supervision, writing – review and editing. All authors contributed to the article and approved the submitted version.

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REFERENCES

Alves, H., Voss, M. W., Boot, W. R., Deslandes, A., Cossich, V., Salles, J. I., et al. (2013). Perceptual-cognitive expertise in elite volleyball players. *Front. Psychol.* 4:36. doi: 10.3389/fpsyg.2013.00036

Aouadi, R., Jlid, M. C., Khalifa, R., Hermassi, S., Chelly, M. S., Van Den Tillaar, R., et al. (2012). Association of anthropometric qualities with vertical jump performance in elite male volleyball players. *J. Sports Med. Phys. Fit.* 52, 11–17.

Arrieta, H., Torres-Unda, J., Gil, S. M., and Irazusta, J. (2016). Relative age effect and performance in the U16, U18 and U20 European basketball championships. *J. Sports Sci.* 34, 1530–1534. doi: 10.1080/02640414.2015.1122204

Balser, N., Lorey, B., Pilgramm, S., Naumann, T., Kindermann, S., Stark, R., et al. (2014). The influence of expertise on brain activation of the action observation network during anticipation of tennis and volleyball serves. *Front. Hum. Neurosci.* 8:568. doi: 10.3389/fnhum.2014.00568

Baptista, F., Rebocho, L. M., Cardadeiro, G., Zymbal, V., and Rosati, N. (2016). Sex- and maturity-related differences in cortical bone at the distal radius and midshaft tibia evaluated by quantitative ultrasonography. *Ultrasound Med. Biol.* 42, 2043–2049. doi: 10.1016/j.ultrasmedbio.2016.04.001

Barrenetxea-Garcia, J., Torres-Unda, J., Esain, I., and Gil, S. M. (2018). Relative age effect and left-handedness in world class water polo male and female players. *Laterality* 24, 259–273. doi: 10.1080/1357650X.2018.1482906

Baxter-Jones, A. D. G., Barbour-Tuck, E. N., Dale, D., Sherar, L. B., Knight, C. J., Cumming, S. P., et al. (2020). The role of growth and maturation during adolescence on team-selection and short-term sports participation. *Ann. Hum. Biol.* 221, 1–8. doi: 10.1080/03014460.2019.1707870

Campos, F., Stanganelli, L. R., Rabelo, F., Campos, L., and Pellegrinotti, Í (2016). The relative age effect in male volleyball championships. *Int. J. Sports Sci.* 6, 116–120.

Carvalho, A., Roriz, P., and Duarte, D. (2020). Comparison of morphological profiles and performance variables between female volleyball players of the first and second division in portugal. *J. Hum. Kinet.* 71, 109–117. doi: 10.2478/hukin-2019-0076

Chung, S. (2015). Body mass index and body composition scaling to height in children and adolescent. *Ann. Pediatr. Endocrinol. Metab.* 20, 125–129. doi: 10.6065/apem.2015.20.3.125

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping, and athlete development. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Deprez, D., Coutts, A. J., Fransen, J., Deconinck, F., Lenoir, M., Vaeyens, R., et al. (2013). Relative age, biological maturation and anaerobic characteristics in elite youth soccer players. *Int. J. Sports Med.* 34, 897–903. doi: 10.1055/s-0032-1333262

Duarte, J. P., Coelho, E. S. M. J., Costa, D., Martinho, D., Luz, L. G. O., RebeloGoncalves, R., et al. (2019). Repeated sprint ability in youth soccer players: independent and combined effects of relative age and biological maturity. *J. Hum. Kinet.* 67, 209–221. doi: 10.2478/hukin-2018-0090

Duncan, M. J., Woodfield, L., and Al-Nakeeb, Y. (2006). Anthropometric and physiological characteristics of junior elite volleyball players. *Br. J. Sports Med.* 40, 649–651. doi: 10.1136/bjsm.2005.021998

Gabbett, T., Georgieff, B., and Domrow, N. (2007). The use of physiological, anthropometric, and skill data to predict selection in a talent-identified junior volleyball squad. *J. Sports Sci.* 25, 1337–1344. doi: 10.1080/02640410601188777

Giannopoulos, N., Vagenas, G., Noutsos, K., Barzouka, K., and Bergeles, N. (2017). Somatotype, level of competition, and performance in attack in elite male Volleyball. *J. Hum. Kinet.* 58, 131–140. doi: 10.1515/hukin-2017-0082

González-Víllora, S., Pastor-Vicedo, J. C., and Cordente, D. (2015). Relative age effect in UEFA championship soccer players. *J. Hum. Kinet.* 47, 237–248. doi: 10.1515/hukin-2015-0079

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 6, 630–637. doi: 10.1080/17461391.2013.775352

Hill, B., and Sotiriadou, P. (2016). Coach decision-making and the relative age effect on talent selection in football. *Eur. Sport Manag. Q.* 16, 292–315.

Jager, J. M., and Schollhorn, W. I. (2007). Situation-orientated recognition of tactical patterns in volleyball. *J. Sports Sci.* 25, 1345–1353. doi: 10.1080/02640410701287230

Joao, P. V., Leite, N., Mesquita, I., and Sampaio, J. (2010). Sex differences in discriminative power of volleyball game-related statistics. *Percept. Mot. Skills* 111, 893–900. doi: 10.2466/05.11.25.pms.111.6.893-900

Johnson, A., Farooq, A., and Whiteley, R. (2017). Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci. Med. Footb.* 1, 157–163. doi: 10.1080/24733938.2017.1283434

Jones, B. D., Lawrence, G. P., and Hardy, L. (2018). New evidence of relative age effects in "super-elite" sportsmen: a case for the survival and evolution of the fittest. *J. Sports Sci.* 36, 697–703. doi: 10.1080/02640414.2017.1332420

Koziel, S. M., and Malina, R. M. (2018). Modified maturity offset prediction equations: validation in independent longitudinal samples of boys and girls. *Sports Med.* 48, 221–236. doi: 10.1007/s40279-017-0750-y

Kwieciński, J., Konarski, J. M., Strzelczyk, R., Krzykała, M., Konarska, A., Bartkowiak, S., et al. (2018). Non-linear relationships between the BMI and physical fitness in polish adolescents. *Ann. Hum. Biol.* 45, 406–413. doi: 10.1080/03014460.2018.1494306

Lidor, R., Arnon, M., Maayan, Z., Gershon, T., and Côté, J. (2014). Relative age effect and birthplace effect in Division 1 female ballgame players—the relevance of sport-specific factors. *Intern. J. Sport Exerc. Psychol.* 12, 19–33. doi: 10.1080/1612197X.2012.756232

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2013.01465

Malina, R. M. (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Res. Q. Exerc. Sport* 85, 157–173. doi: 10.1080/02701367.2014.897592

Marcelino, R., Afonso, J., Moraes, J., and Isabel, M. (2014). Determinants of attack players in high-level men's volleyball. *Kinesiology* 46, 234–241.

Mohamed, H., Vaeyens, R., Matthys, S., Multael, M., Lefevre, J., Lenoir, M., et al. (2009). Anthropometric and performance measures for the development of a talent detection and identification model in youth handball. *J. Sports Sci.* 27, 257–266. doi: 10.1080/02640410802482417

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Nakata, H., and Sakamoto, K. (2012). Sex differences in relative age effects among Japanese athletes. *Percept. Mot. Skills* 115, 179–186. doi: 10.2466/10.05.17.pms.115.4.179-186

Nikolaidis, P., Afonso, J., Buśko, K., Ingebrigtsen, J., Chtourou, H., and Martin, J. (2015). Positional differences of physical traits and physiological characteristics in female volleyball players – the role of age. *Kinesiology* 47, 75–81.

Okazaki, F. H., Keller, B., Fontana, F. E., and Gallagher, J. D. (2011). The relative age effect among female Brazilian youth volleyball players. *Res. Q Exerc. Sport* 82, 135–139. doi: 10.1080/02701367.2011.10599730

Papadopoulou, S., Papadopoulou, S., Rosemann, T., Knechtle, B., and Nikolaidis, P. (2019). Relative age effect on youth female volleyball players: a pilot study on its prevalence and relationship with anthropometric and physiological characteristics. *Front. Psychol.* 10:2737. doi: 10.3389/fpsyg.2019.02737

Parma, J. O., and Penna, E. M. (2018). The relative age effect on brazilian elite volleyball. *J. Phys. Educ.* 29:2455.

Pion, J. A., Fransen, J., Deprez, D. N., Segers, V. I., Vaeyens, R., Philippaerts, R. M., et al. (2015). Stature and jumping height are required in female volleyball, but motor coordination is a key factor for future elite success. *J. Strength Cond. Res.* 29, 1480–1485. doi: 10.1519/jsc.0000000000000778

Praxedes, A., Moreno, A., Garcia-Gonzalez, L., Pizarro, D., and Del Villar, F. (2017). The relative age effect on soccer players in formative stages with different sport expertise levels. *J. Hum. Kinet.* 60, 167–173. doi: 10.1515/hukin-2017-0100

Ramos, S., Volossovitch, A., Paulo Ferreira, A., Fragoso, I., and Massuça, L. (2019). Differences in maturity, morphological and physical attributes between players selected to the primary and secondary teams of a Portuguese Basketball elite academy. *J. Sports Sci.* 37, 1681–1689. doi: 10.1080/02640414.2019.1585410

Reed, K. E., Parry, D. A., and Sandercock, G. R. H. (2017). Maturational and social factors contributing to relative age effects in school sports: data from the London youth games. *Scand. J. Med. Sci. Sports* 27, 2070–2079. doi: 10.1111/sms.12815

Rikberg, A., and Raudsepp, L. (2011). Multidimensional performance characteristics in talented male youth volleyball players. *Pediatr. Exerc. Sci.* 23, 537–548. doi: 10.1123/pes.23.4.537

Rubajczyk, K., Swierzko, K., and Rokita, A. (2017). Doubly disadvantaged? The relative age effect in Poland's basketball players. *J. Sports Sci. Med.* 16, 280–285.

Salinero, J., González, B., Burillo, P., and Lesma, M. (2013). Relative age effect in European professional football. Analysis by position. *J. Hum. Sport Exerc.* 8, 966–973. doi: 10.4100/jhse.2013.84.07

Sandercock, G. R. H., Taylor, M. J., Voss, C., Ogunleye, A. A., Cohen, D. D., and Parry, D. A. (2013). Quantification of the relative age effect in three indices of physical performance. *J. Strength Cond. Res.* 27, 3293–3299. doi: 10.1519/JSC.0b013e318291b28d

Sattler, T., Hadzic, V., Dervisevic, E., and Markovic, G. (2015). Vertical jump performance of professional male and female volleyball players: effects of playing position and competition level. *J. Strength Cond. Res.* 29, 1486–1493.

Schorer, J., Cobley, S., Busch, D., Brautigam, H., and Baker, J. (2009). Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scand J. Med. Sci. Sports* 19, 720–730.

Silva, M., Lacerda, D., and Joao, P. V. (2014). Game-related volleyball skills that influence victory. *J. Hum. Kinet.* 41, 173–179. doi: 10.2478/hukin-2014-0045

Skorski, S., Skorski, S., Faude, O., Hammes, D., and Meyer, T. (2016). The relative age effect in German elite youth soccer: implications for a successful career. *Int. J. Sports Physiol. Perform.* 11, 370–376.

Tsoukos, A., Drikos, S., Brown, L. E., Sotiropoulos, K., Veligekas, P., and Bogdanis, G. C. (2019). Anthropometric and motor performance variables are decisive factors for the selection of junior national female volleyball players. *J. Hum. Kinet.* 67, 163–173.

van Rossum, J. H. A. (2006). Relative age effect revisited: findings from the dance domain. *Percept. Mot. Skills* 102, 302–308. doi: 10.2466/Pms.102.2.302-308

Vargas, J., Loureiro, M., Nikolaidis, P. T., Knechtle, B., Laporta, L., Marcelino, R., et al. (2018). Rethinking monolithic pathways to success and talent identification: the case of the women's Japanese volleyball team and why height is not everything. *J. Hum. Kinet.* 64, 233–245.

Werneck, F. Z., Coelho, E. F., De Oliveira, H. Z., Júnior, D. B. R., Almas, S. P., De Lima, J. R. P., et al. (2016). Relative age effect in olympic basketball athletes. *Sci. Sports* 31, 158–161.

Young, W. (2015). Agility and change of direction speed are independent skills: implications for agility in invasion sports. *Int. J. Sports Sci. Coach.* 10, 159–169.

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Appreciating Factors Beyond the Physical in Talent Identification and Development: Insights From the FC Barcelona Sporting Model

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FC Barcelona is a multi-sport organization that adopts a talent identification approach that emphasizes the technical, psychological, and perceptual–cognitive attributes. It is unclear within this type of sporting selection model whether the relative age effect (RAE) exists. Consequently, the aim of the study was to evaluate the RAE across multiple sports and age groups at FC Barcelona. The birthdates of all players ($n = 6,542$) affiliated to each sport [male basketball ($n = 1,013$), male ($n = 3,012$) and female ($n = 449$) soccer, male futsal ($n = 761$), male handball ($n = 999$), and male indoor roller hockey ($n = 308$)] across all age groups from U10 to Senior were recorded. These were then categorized into quartiles from the start of the selection year (Q1 = Jan–Mar; Q2 = Apr–Jun; Q3 = Jul–Sep; Q4 = Oct–Dec) and analyzed for (a) each sport; (b) each age group, irrespective of the sport; and (c) each age group within each sport, using Chi-squared statistics and odds ratios (ORs) with 95% confidence intervals (CIs). Birthdates across the entire club revealed a RAE (Q1 = 46.1%, Q2 = 27.1%, Q3 = 17.1%, and Q4 = 9.7%, $\chi^2 = 29.8$, $P < 0.01$), with OR in Q1, Q2, and Q3 representing a 4.76 (95% CIs: 1.96–11.57), 2.80 (1.12–7.03), and 1.77 (0.67–4.63) increased likelihood for selection when compared to Q4, respectively. Despite FC Barcelona's approach to talent identification and development, the RAE was still present within youth age groups (<18 years old). The current findings provide support that the RAE is more prevalent within regionally popular sports and reduces with increasing age; however, given the talent identification processes within FC Barcelona's sporting model, additional factors beyond the physical attributes, such as enhanced psychological and perceptual–cognitive attributes, in those born earlier in the selection year might further influence the RAE. Consequently, current results provide indirect evidence to suggest that sociological and psychological determinants might be a greater influence on the presence of RAE in sporting environments that prefer to consider technical and perceptual–cognitive attributes in their talent development programs.

Keywords: talent identification, talent development, team sports, technical, selection bias

INTRODUCTION

Relative age effects (RAEs) exist when there is a distinct over-representation of players born earlier in the selection year for a given cohort. Researchers suggest that this is due to variations within both the occurrence and rate of growth and maturation within youth sport populations (Malina et al., 2017) when stratified by chronological age groups. Indeed, the RAE was significantly correlated with a team's final rankings in U-17 German first leagues for soccer (Augste and Lames, 2011). Recently, Bezuglov et al. (2019) found the RAE to be highly prevalent within Russian youth soccer and was associated with the level of competitiveness, as the RAE was most pronounced in the top tier of junior Russian soccer academies and national teams. With respect to other sports, Ibañez et al. (2018) found the RAE to be prevalent within elite U-18 basketball, according to position. While the RAE has potential positive implications for success in specific age groups, it has potentially detrimental implications for talent identification and talent development in youth populations. A preference for immediate "success" potentially results in a maturation-selection phenomenon in which there is a preference for selecting early maturers, who display superior physical qualities than their late maturing counterparts (Lovell et al., 2015; Wattie et al., 2015). While the RAE and maturity status should not be viewed as the same construct (Pena-Gonzalez et al., 2018), the unintended consequence is that the less biologically mature individual (those born later in the selection year) is viewed negatively due to their physical disadvantage (Esteva et al., 2006; Lovell et al., 2015; Malina et al., 2017). A potential consequence is that biologically immature, but technically skillful players are overlooked or drop out in the developmental stages of youth development programs and never attain their full potential (Figueiredo et al., 2009; Bezuglov et al., 2019). Physical advantages in strength and power, which are associated with growth and maturation, will have a positive impact on an individual's ability to perform specific movement demands commonly exhibited in team sports (e.g., accelerations, sprints, tackles, and jumps) and are often favored within talent identification and talent development programs (Lovell et al., 2015).

Lovell et al. (2015), however, reported a strong RAE in prepubertal age groups (U9) across numerous English soccer developmental programs, in which the impact of growth and maturation is negligible. This finding is supported by Cobley et al. (2009) meta-analyses, which display a RAE in prepubertal age groups for ice hockey, tennis, and soccer. This suggests that non-physical factors should also be considered when examining the RAE in youth sport. As such, sociological and psychological factors that impact on the prevalence of the RAE should be considered when examining those involved in the selection and developmental processes in high-level youth sport. Indeed, earlier enrolment of relatively older players (players born earlier in the selection year) from a young age is likely to lead to a greater amount of exposure to quality systematic training, formal and expert coaching, and increased access to superior facilities, than their relatively younger counterparts (players born later in the selection year). Moreover, the relationships between youth players and the key stakeholders within the talent identification and development processes should also be considered when exploring RAEs within sport. Research from Larkin and O'Connor (2017) demonstrated that coaches and scouts emphasized the importance of technical attributes in the talent identification and development processes, providing further support that a wider array of factors (beyond the physical) need to be considered to develop an improved understanding of the RAE within youth sport. Consequently, research examining RAEs in sport should benefit from utilizing appropriate theoretical models that enable researchers and practitioners to develop a wider appreciation of the factors that contribute to the prevalence of the RAE, and the interdependent relationships between these factors (Hancock et al., 2013; Wattie et al., 2015). In addition, researchers have often focused on the RAE within a single sport, and while comparisons between published literature can be made, single-study research assessing the presence of the RAE across multiple sports and age groups is limited. Wide-ranging sport clubs (i.e., those that are composed of multiple sports and ages within the same club environment) provide an opportunity to explore the theoretical models proposed by Wattie et al. (2015) and Hancock et al. (2013) within a single, elite sports environment. One such club is FC Barcelona, which includes highly trained athletes, ranging in age from U10 to professional adult status, including (male) basketball, futsal, handball, and indoor roller hockey, as well as male and female soccer.

Previous RAE research might be regarded as atheoretical and limited to observational studies; however, both Wattie et al. (2015) and Hancock et al. (2013) have proposed theoretical models to better explain RAEs in sport. Hancock et al. (2013) propose a social agent model, highlighting the *Matthew* effect, *Pygmalian* effect, and *Galatea* effect as key concepts of the theory that can be used to help explain the influence social agents have on RAEs. For example, Hancock et al. (2013) suggest that initial RAEs (i.e., in younger age groups) are influenced by the Matthew effect, with relatively older players being enrolled (by their parents) in sport at an early age. This results in these children acquiring advanced skills and capabilities (through structured training) in comparison to their relatively younger counterparts and providing coaches with a talent pool that is filled with relatively older athletes (Hancock et al., 2013). Subsequently, the Pygmalian effect highlights the impact that perceived expectations, from others (whether subconsciously or consciously imposed), can have on an individual's outcomes. Finally, once individual expectations have been inferred, the Galatea effect suggests that players will act congruently with these expectations (Hancock et al., 2013). Consequently, Hancock et al. (2013) emphasize the impact social agents might have upon RAEs in sport, arguing that social agents often falsely associate physical maturity with actual performance (skill and physical) differences (Larkin and O'Connor, 2017). Wattie et al. (2015) developed a constraints-based model in which environmental, individual, and task constraints need to be considered to develop an understanding of the existence or non-existence of RAEs. Wattie et al. (2015) constraints-based model suggests that the individual constraints [composed of structural factors (i.e., anthropometric and physical characteristics) and functional factors (i.e., psychological characteristics)], task constraints (i.e., sporting demands), and environmental constraints (i.e., broader social constructs) need to be considered when examining RAEs in sport.

Meta-analyses exploring the RAE in sport have demonstrated that the presence of the RAE appears to be influenced by interactions between developmental stages/age categories, competition/skill level, and sporting demands (i.e., sporting context and type) (Cobley et al., 2009; Smith et al., 2018). Alongside the physical traits that are required for success at the elite level, the FC Barcelona talent identification model emphasizes technical and perceptual–cognitive attributes. This is supported by Gyarmati et al. (2014) evaluation of FC Barcelona's first team's unique style of play in men's soccer, when compared to other top-level European teams. This approach is advocated throughout the youth setup and is a product of synergizing the complex and varied determinants of team sport performance (Mallo, 2020). Therefore, FC Barcelona presents an opportune professional multi-sport model, in which numerous team sports (basketball, soccer, indoor football, handball, and indoor roller hockey) and age groups can be investigated in relation to the theoretical models proposed by Hancock et al. (2013) and Wattie et al. (2015). Consequently, an improved understanding of the prevalence of the RAE within a given sporting context (FC Barcelona), which emphasizes the technical and perceptual–cognitive attributes within their approach to talent identification and development, is likely to have wider implications for the influence of RAE for both talent identification and talent development in other sporting institutions that adopt a similar approach. Specifically, the emphasis on technical and perceptual–cognitive attributes within this context may provide further insights into the extent to which factors beyond the physical, impact upon RAEs in sport.

Therefore, the aim of the present study was to evaluate the RAE across multiple sports at FC Barcelona, which, alongside the required physical traits for elite level success, emphasize the technical and perceptual–cognitive attributes in their talent identification and development processes. This will be done by examining the birthdate distributions within (a) each sport; (b) each age group (U10, U12, U14, U16, U18, and Senior Squads), irrespective of the sport; and (c) each age group within each sport. It was hypothesized that based on FC Barcelona's talent identification model, the RAE would be less prevalent across all age groups and sports than has been previously reported within the RAE literature. However, it was hypothesized that the RAE would remain more prevalent within the younger age groups, relative to the senior squads. Finally, across sports and irrespective of FC Barcelona's talent identification model, it was hypothesized that the RAE would be more prevalent in basketball than other sports, due to the specific sporting (physical) demands, irrespective of the unified club philosophy.

MATERIALS AND METHODS

Ethical approval was gained from the Ethics Committee for Clinical Research of the Catalan Sports Council (17/2018/CEICEGC). The birthdates of all players (n = 6,542) affiliated to each sport [male (n = 3,012) and female (n = 449) soccer, male basketball (n = 1,013), male futsal (n = 761), male handball (n = 999), and male indoor roller hockey (n = 308)] within FC Barcelona and across all age groups [U10 (n = 588), U12 (n = 755), U14 (n = 1,488), U16 (n = 1,578), U18 (n = 944), and Senior (n = 1,189)] were recorded. Data from female athletes were only available for soccer. At the senior level, the men's soccer team competes domestically in La Liga and internationally in the UEFA Champions League. The women's soccer team competes domestically in the Primera Division and internationally in the UEFA Women's Champions League. The basketball team competes domestically in Liga ACB and internationally in the EuroLeague. The futsal team competes domestically in the Primera Division and internationally in the UEFA Futsal Cup. The handball team competes domestically in the Liga ASOBAL and internationally in the European Champions Cup. Finally, the indoor roller hockey competes domestically in the OK Liga and internationally in the European League. Finally, all senior teams within each of these sports are recognized as professional teams.

Individuals' birthdates were then categorized into relative age quartiles (Q) from the start of the selection year (Q1 = Jan–Mar; Q2 = Apr–Jun; Q3 = Jul–Sep; Q4 = Oct–Dec). Birthdate distributions across quartiles were then analyzed for (a) each sport; (b) each age group, irrespective of the sport; and (c) each age group within each sport, using Chi squared (χ^2) statistics and by calculating odds ratios (ORs) and 95% confidence intervals (CIs) for the quartile distributions. The Chi-squared statistic assessed differences between the observed and expected birthdate distributions, with expected birthdate distributions being calculated using available data from birth statistics for Spain, from 2015 and 2016 (Statista, 2018). In accordance with the study by Lovell et al. (2015), reference values were obtained from the general population to provide an indication of the birthdate distribution that participate within grassroots-level sport (i.e., the talent pool from which these players are selected). This resulted in reference values of 24.4, 24.3, 26.1, and 25.1% for Q1, Q2, Q3, and Q4, respectively. Chi-squared statistics, however, do not reveal the magnitude and direction of the existing relationship and therefore ORs were also calculated to examine the bias of birthdate distributions within sub-groups (Q1, Q2, Q3, and Q4). The OR compared the birthdate distribution of a particular quartile (Q1, Q2, or Q3) with the reference group, which consisted of the relatively youngest players (Q4). A higher OR indicates an increased representation of players who were born in that particular quartile compared to the reference quartile Q4 and were considered significant when the CI range did not include a value $\leq$1.00. Finally, where appropriate, the alpha level was set at $P < 0.05$.

RESULTS

The frequency and percentage distributions of players' birth quartiles within each sport are presented in **Table 1**. The Chi-squared showed significant deviations across quartiles for all sports, with basketball and male soccer displaying substantially

TABLE 1 | Birth quartiles by sport across all age groups.

Sport	*n*	Birthdate distribution # (%)				Odds ratios (95% CI)			Chi-squared
		Q1	Q2	Q3	Q4	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	χ^2
Basketball	1,013	506 (50.0)	279 (27.5)	157 (15.5)	71 (7.0)	7.1 (2.7–18.7)	3.9 (1.5–10.7)	2.2 (0.8–6.3)	44.7*
Soccer (Male)	3,012	1599 (53.1)	798 (26.5)	422 (14.0)	193 (6.4)	8.3 (3.1–22.3)	4.1 (1.5–11.5)	2.2 (0.7–6.5)	53.6*
Soccer (Female)	449	138 (30.7)	146 (32.5)	90 (20.0)	75 (16.7)	1.8 (0.8–4.1)	1.9 (0.9–4.4)	1.2 (0.5–2.8)	8.7*
Futsal	761	297 (39.0)	189 (24.8)	170 (22.3)	105 (13.8)	2.8 (1.2–6.5)	1.8 (0.8–4.3)	1.6 (0.7–3.9)	14.5*
Handball	999	363 (36.3)	273 (27.3)	212 (21.2)	151 (15.1)	2.4 (1.1–5.4)	1.8 (0.8–4.2)	1.4 (0.6–3.3)	11.1*
Roller hockey	308	106 (34.4)	86 (27.9)	74 (24.0)	42 (13.6)	2.5 (1.1–5.8)	2.0 (0.9–4.8)	1.8 (0.7–4.2)	10.1*

Significant effect at an alpha level of $P < 0.05$. Q1 = Jan–Mar, Q2 = Apr–Jun, Q3 = Jul–Aug, and Q4 = Sep–Oct.

TABLE 2 | Birth quartiles by age groups across all sports.

Age group	*n*	Birthdate distribution # (%)				Odds ratios (95% CI)			Chi-squared
		Q1	Q2	Q3	Q4	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	χ^2
U10	588	327 (55.6)	177 (30.1)	66 (11.2)	18 (3.1)	18.2 (5.1–65.2)	9.8 (2.7–36.1)	3.7 (0.9–14.6)	69.2*
U12	755	376 (49.8)	220 (29.1)	101 (13.4)	58 (7.7)	6.5 (2.5–16.6)	3.8 (1.4–10.0)	1.7 (0.6–5.0)	45.7*
U14	1,488	737 (49.5)	401 (26.9)	228 (15.3)	122 (8.2)	6.0 (2.4–15.2)	3.3 (1.3–8.6)	1.9 (0.7–5.0)	42.0*
U16	1,578	756 (47.9)	430 (27.2)	256 (16.2)	136 (8.6)	5.6 (2.2–13.9)	3.2 (1.2–8.1)	1.9 (0.7–5.1)	38.7*
U18	944	437 (46.3)	243 (25.7)	173 (18.3)	91 (9.6)	4.8 (2.0–11.7)	2.7 (1.1–6.7)	1.9 (0.7–5.0)	31.7*
Senior	1,189	376 (31.6)	300 (25.2)	301 (25.3)	212 (17.9)	1.8 (0.8–3.9)	1.4 (0.6–3.2)	1.4 (0.6–3.3)	4.2

Significant effect at an alpha level of $P < 0.05$. Q1 = Jan–Mar, Q2 = Apr–Jun, Q3 = Jul–Aug, and Q4 = Sep–Oct.

larger χ^2 values (44.7 and 53.6, respectively) than other sports. All sports, excluding female soccer, displayed the highest percentage distribution of birthdates within Q1, with a progressive decline to Q4. Female soccer, however, displayed a larger percentage distribution of birthdates within Q2 (32.5%), when compared to Q1 (30.1%). OR revealed that basketball and male soccer had higher and comparable RAE, with female soccer, futsal, handball, and roller hockey demonstrating weaker, though significant, effects.

The frequency and percentage distributions of players' birth quartiles within each age group are presented in **Table 2**. The χ^2 showed significant deviations across quartiles for all youth age groups (U10, U12, U14, U16, and U18). Within the senior squads, however, there was no significant difference between the birthdate distribution of senior players and the expected birthdate distributions ($\chi^2 = 4.2$, $P = 0.24$). In all age groups, Q1 birthdates were most overrepresented, with a progressive decline to Q4—though the inter-quartile differences dissipated with increasing age. Analysis of the RAE within each age group, using OR analysis, revealed that the RAE was most prevalent within the U10 age group, with U12 to U18 age groups still displaying a RAE, although there was shown to be a reduction in OR values between Q1, Q2, Q3, and the reference value of Q4, with increasing age.

The frequency and percentage distributions of players' birth quartiles within each age group and each sport are presented in **Table 3**. According to the χ^2 statistic, the RAE was present within all youth age groups (U18 and below) and across all sports excluding the roller hockey U12 age group, in which there was a substantially smaller number of players. In senior squads, the χ^2 statistic was shown to be significant within basketball, male soccer, and roller hockey; however, the value of the χ^2 statistic in all senior squads was lower than the χ^2 values provided in the younger age groups, for the respective sports. OR analysis supported these findings, demonstrating that there is a consistent bias toward individuals born early in the selection year, particularly within those born within Q1. The largest OR values were found in the younger age groups within basketball and male soccer, in which there were a higher *number of players in each sport*. The OR values within female soccer, futsal, handball, and roller hockey also support the presence of the RAE; however, the extent to which there is a bias (e.g., the size of the OR) for those born earlier within the selection year was lower than those found in basketball and soccer.

DISCUSSION

The major findings from this novel investigation were that (a) the RAE is present within a range of sports, but that it is most prevalent in sports that may be regarded as regionally popular (e.g., basketball and male soccer), and (b) the RAE is apparent within all youth age groups (U10–U18s), becoming less prevalent with increasing age, and then negligible within senior squads. Consequently, both sport and age appear to be key factors with regard to the presence and extent of the RAE and should be considered when undertaking research within RAEs in sport and when applying any theoretical models. This pattern has emerged irrespective of the underlying club philosophy, which emphasizes

TABLE 3 | Birth quartiles by sport and age groups.

All sport	Age group		Birthdate distribution # (%)				Odds ratios (95% CI)			Chi-squared
		n	Q1	Q2	Q3	Q4	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	χ^2
Basketball	U10						*No Squad*			
	U12						*No Squad*			
	U14	333	182 (54.7)	95 (28.5)	42 (12.6)	14 (4.2)	13.0 (4.2–40.1)	6.8 (2.1–21.7)	3.0 (0.9–10.3)	62.8*
	U16	303	172 (56.8)	81 (26.7)	38 (12.5)	12 (4.0)	14.3 (4.5–45.7)	6.8 (2.1–22.2)	3.2 (0.9–11.1)	68.2*
	U18	140	72 (51.4)	36 (25.7)	25 (17.9)	7 (5.0)	10.3 (3.5–30.1)	5.1 (1.7–15.6)	3.6 (1.2–11.1)	48.7*
	Senior	237	80 (33.8)	67 (28.3)	52 (21.9)	38 (16.0)	2.1 (0.9–4.8)	1.8 (0.8–4.0)	1.4 (0.6–3.2)	8.3*
Soccer (Male)	U10	588	327 (55.6)	177 (30.1)	66 (11.1)	18 (3.1)	18.2 (5.1–65.2)	9.8 (2.7–36.1)	3.7 (0.9–14.5)	69.3*
	U12	573	308 (53.8)	167 (29.1)	64 (11.2)	34 (5.9)	9.1 (3.3–24.5)	4.9 (1.7–13.9)	1.9 (0.6–5.9)	59.6*
	U14	561	307 (54.7)	147 (26.2)	66 (11.8)	41 (7.3)	7.5 (2.9–19.4)	3.6 (1.3–9.7)	1.6 (0.6–4.7)	58.3*
	U16	535	301 (56.3)	126 (23.6)	77 (14.4)	31 (5.8)	9.7 (3.5–26.9)	4.1 (1.4–11.8)	2.5 (0.8–7.6)	61.9*
	U18	436	228 (52.3)	101 (23.2)	77 (17.7)	30 (6.9)	7.6 (2.9–20.0)	3.4 (1.2–9.3)	2.6 (0.9–7.3)	47.9*
	Senior	319	128 (40.1)	80 (25.1)	72 (22.6)	39 (12.2)	3.3 (1.4–7.7)	2.1 (0.9–4.9)	1.9 (0.8–4.5)	17.3*
Soccer (Female)	U10						*No Squad*			
	U12						*No Squad*			
	U14	115	46 (40.0)	37 (32.3)	18 (15.7)	14 (12.2)	3.3 (1.4–7.7)	2.6 (1.1–6.3)	1.3 (0.5–3.3)	23.5*
	U16	133	41 (30.8)	47 (35.3)	26 (19.5)	19 (14.3)	2.2 (0.9–5.0)	2.5 (1.1–5.7)	1.4 (0.6–3.3)	13.0*
	U18						*No Squad*			
	Senior	201	51 (25.4)	62 (30.8)	46 (22.9)	42 (20.9)	1.2 (0.5–2.7)	1.5 (0.7–3.2)	1.1 (0.5–2.5)	2.9
Futsal	U10						*No Squad*			
	U12	155	60 (38.7)	45 (29.0)	33 (21.3)	17 (11.0)	3.5 (1.5–8.4)	2.7 (1.1–6.4)	1.9 (0.8–4.9)	18.2*
	U14	161	74 (46.0)	40 (24.8)	33 (20.5)	14 (8.7)	5.3 (2.1–13.2)	2.9 (1.1–7.4)	2.4 (0.9–6.2)	31.1*
	U16	140	63 (45.0)	44 (31.4)	23 (16.4)	10 (7.1)	6.3 (2.4–16.5)	4.4 (1.7–11.8)	2.3 (0.8–6.5)	36.1*
	U18	143	56 (39.2)	36 (25.2)	28 (19.6)	23 (16.1)	2.4 (1.1–5.4)	1.6 (0.7–3.6)	1.2 (0.5–2.9)	13.9*
	Senior	162	44 (27.2)	24 (14.8)	53 (32.7)	41 (25.3)	1.1 (0.5–2.3)	0.6 (0.3–1.4)	1.3 (0.6–2.8)	5.7
Handball	U10						*No Squad*			
	U12						*No Squad*			
	U14	238	94 (39.5)	60 (25.2)	52 (21.8)	32 (13.4)	2.9 (1.3–6.7)	1.9 (0.8–4.5)	1.6 (0.7–3.9)	15.8*
	U16	398	151 (37.9)	112 (28.1)	80 (20.1)	55 (13.8)	2.8 (1.2–6.3)	2.0 (0.9–4.8)	1.5 (0.6–3.5)	14.6*
	U18	150	59 (39.3)	47 (31.3)	23 (15.3)	21 (14.0)	2.8 (1.2–6.4)	2.2 (1.0–5.2)	1.1 (0.4–2.7)	20.5*
	Senior	213	59 (27.7)	54 (25.4)	57 (26.8)	43 (20.2)	1.4 (0.6–3.1)	1.3 (0.6–2.8)	1.3 (0.6–3.0)	1.5
Roller hockey	U10						*No Squad*			
	U12	27	8 (29.6)	8 (29.6)	4 (14.8)	7 (25.9)	1.1 (0.5–2.5)	1.1 (0.5–2.5)	0.6 (0.3–1.3)	7.2
	U14	80	34 (42.5)	22 (27.5)	17 (21.3)	7 (8.8)	4.9 (2.0–12.1)	3.1 (1.2–8.1)	2.4 (0.9–6.4)	25.4*
	U16	69	28 (40.6)	20 (29.0)	12 (17.4)	9 (13.0)	3.1 (1.4–7.2)	2.2 (0.9–5.2)	1.3 (0.5–3.3)	20.5*
	U18	75	22 (29.3)	23 (30.7)	20 (26.7)	10 (13.3)	2.2 (0.9–5.2)	2.3 (1.0–5.4)	2.0 (0.9–4.7)	8.3*
	Senior	57	14 (24.6)	13 (22.8)	21 (36.8)	9 (15.8)	1.6 (0.7–3.6)	1.4 (0.6–3.4)	2.3 (1.0–5.2)	8.0*

Significant effect at an alpha level of $P < 0.05$.

the technical and perceptual–cognitive characteristics of the player. Indeed, current findings may suggest that there is a bias toward individuals who are born early in the selection year, despite club talent identification (and development) criteria that favor the more "technically" dominant athlete. It is possible that physical attributes might still be a determinant within the talent identification and development model, despite the overarching technique-based recruitment model of FC Barcelona. Equally, it could be postulated that social agents as well as individual, environmental, and task constraints, proposed in the theoretical models of Hancock et al. (2013) and Wattie et al. (2015), falsely exacerbate the prevalence of the RAE in which physical attributes are a contributing factor.

Within the current study, the RAE was greater within basketball and male soccer, as evidenced by the χ^2 statistic and the OR analysis. Furthermore, while the extent of the RAE decreased with increasing age, the χ^2 statistics still revealed a significant difference between the birthdate distribution of senior players and the expected birthdate distributions (across birth quartiles) for both basketball ($\chi^2 = 8.3, P = 0.03$) and male soccer ($\chi^2 = 17.3, P = 0.0006$) players. OR analysis within these sports suggests that the RAE was more prevalent within the younger age groups; however, the percentage distribution of birthdates across quartiles should be acknowledged, as a smaller percentage within Q4 will inflate the OR values for Q1, Q2, and Q3. All youth age groups in basketball and male soccer displayed a percentage distribution of birthdates within Q1 that was >50%, suggesting a consistent bias toward selecting those individuals born earlier in the selection year (i.e., chronologically older individuals). Specifically, the more prevalent RAE in basketball could be linked to the fact that position specificity is an issue even at a young age, with individuals of high stature being favored. Sallett et al. (2005) demonstrated that all positions within basketball, other than the point guard where technical (ball handling) skills are key, emphasize stature as a pre-requisite and therefore taller players tend be selected, thus favoring those born earlier in the selection year, leading to an anthropometric manifestation of the RAE (Sallett et al., 2005). Likewise, selection processes in soccer (talent identification) often favor those with superior levels of physicality (Lovell et al., 2015), as well as those of increased stature within certain positions (e.g., goalkeeper and central defender). Again, this results in a bias toward those born earlier in the selection year (Q1 and Q2), as such individuals are likely, but not necessarily (Pena-Gonzalez et al., 2018), to be of increased growth and advanced maturity, in comparison to individuals born later in the selection year (Q3 and Q4). In contrast, recent research from Ibañez et al. (2018) found the RAE among U18 basketball players to be most prevalent within the guard position and least prevalent within centers. This suggests that physical prowess and anthropometric advantages might not be as influential as initially thought, as guards need high levels of technical, tactical, and perceptual–cognitive abilities (Ibañez et al., 2018). Consequently, an increased prevalence of the RAE within this position suggests that relatively older players might enhance their sport-specific performance skills faster than their relatively younger peers. This might be a result of an increased exposure to sport-specific motor experiences, increased exposure to quality coaches and facilities as well as regular involvement in higher competition levels from a younger age, which are a consequence of a selection bias of those born earlier in the year within younger age groups (Ibañez et al., 2018). In support of this, Figueiredo et al. (2019) found limited differences between players, across birth quartiles, for functional capacities, soccer skills, goal orientation, and coach evaluation of potential; yet, coaches tended to rate players born in Q1 as higher in potential. This aligns with the context of the current study, as the FC Barcelona club philosophy emphasizes technical, psychological, and perceptual–cognitive characteristics rather than prioritizing physical precocity; however, the RAE is still prevalent within this context.

In combination with previous research, current results might be explained in accordance with the theoretical models proposed by Hancock et al. (2013) and Wattie et al. (2015), which propose theoretical frameworks that highlight key factors that contribute to the false association between physical maturity and actual performance. Within the current study, findings from female soccer, futsal, handball, and roller hockey displayed a lower RAE in comparison to basketball and male soccer and were more inconsistent with regard to the presence of the RAE across age groups. Both futsal and handball are played on a smaller playing surface (Barbero-Alvarez et al., 2008; Povoas et al., 2012), which might reduce the emphasis on physicality in comparison to other sports. This could diminish the individual and environmental constraints, resulting in a reduced prevalence of the RAE, when compared to basketball and soccer. Conversely, the importance of technical proficiency within soccer (Helsen et al., 2005; Larkin and O'Connor, 2017) and basketball (Ibañez et al., 2018) should not be underestimated, particularly given the emphasis on "technique" within the underlying club philosophy in the current study. Consequently, the individual and environmental constraints within these sports might exacerbate the RAE (Wattie et al., 2015).

Theoretical frameworks provided by Hancock et al. (2013) and Wattie et al. (2015) might be adapted depending on the context in which the RAE is being examined. The less prevalent RAEs stated above may be a consequence of a reduction in the extent to which social agents (Hancock et al., 2013) or "constraints" (Wattie et al., 2015) influence the prevalence of the RAE. For example, in sports of reduced popularity, the Matthew effect is likely to be less evident, as these are not "sports" that appear to be encountered at an early age (as evidenced in **Table 3**). Therefore, the reduced popularity of a sport may diminish the extent to which social agents influence the talent identification and developmental processes (from an early age), resulting in a smaller and more equitable talent pool to draw from Cobley et al. (2009) and Hancock et al. (2013), and a subsequent reduction in the RAE. In addition, sports regarded as regionally popular are likely to lead to increased levels of competitiveness from an early age. As such, increased levels of competitiveness have been shown to exacerbate the RAE (Bezuglov et al., 2019) and this might be due to the manner in which the social agents involved in the talent identification and development processes interpret and implement a club's philosophy. Therefore, within the current context, despite the unified approach to talent identification and development, the actual implementation of this approach might differ from one sport to another, as a result of the sport-specific contextual factors (e.g., competitiveness). Consequently, theoretical models and future research seeking to better explain the RAE should consider whether the influence of the proposed contributing factors (i.e., social agents or theories, growth and maturation, and physical prowess) alters depending on the contextual factors (i.e., age, sport, gender, and playing level). Indeed, the current results are supported by Cobley et al. (2009) meta-analysis, which also found the highest Q1:Q4 OR in basketball and soccer, when compared to ice hockey, baseball, volleyball, and American football. However, given the large number of studies compared within the meta-analysis by Cobley et al. (2009) and the differing sporting contexts and cultures, there is an inability to gain an understanding of the popularity or profile of each sport, and the surrounding contextual factors, within each of the respective studies. As such, the current paper supports and extends on the existing literature and provides indirect evidence that supports the use and application of the theoretical models proposed by Hancock et al. (2013) and Wattie et al. (2015).

Present results demonstrated a persistent, but not universal, bias toward selecting individuals born early in the selection year, particularly within the younger age groups and more high-profile sports. Current results also demonstrate that the presence of the RAE diminished with increasing age, particularly within senior squads, a finding that is supported by previous research (Helsen et al., 2005; Esteva et al., 2006; Lovell et al., 2015). Indeed, similar to the present findings, Lovell et al. (2015) reported smaller OR between Q1 and Q4 in U17 and U18 soccer players, in comparison to younger age groups (U9–U16). Incidentally, while the composition of the theoretical models proposed by Hancock et al. (2013) and Wattie et al. (2015) remains stable with increasing age, the variance to which the specific social agents (and theories) or constraints impacts upon one individual to another is likely to reduce with increasing age. For example, within younger age groups, particularly in high-profile sports, the Pygmalian and Galatea effects might be particularly prevalent at both ends of the spectrum (positive and negative), due to the likely variation in a range of abilities resulting in the presence of low and high expectations. However, as players age, the impact of the Pygmalian and Galatea effects is likely to be reduced as the variation in ability is decreased and the majority of coaches and players will have high expectations, ultimately leading to professional adult status where all involved should be able to perform at a high level and have high expectations. However, the smaller disparities in growth and maturation, comparable levels in physical performance (Lovell et al., 2015), and the greater levels of exposure to training with increasing age should also be considered in relation to the reduced prevalence of the RAE.

As the RAE is also witnessed in education (Jeronimus et al., 2015), there are implications regarding learning capabilities in sport (Pena-Gonzalez et al., 2018). The philosophy of FC Barcelona (i.e., focus on technical and perceptual–cognitive attributes) means that key performance attributes are related to learning capabilities (e.g., decision-making and game intelligence); yet, these are understudied variables in RAE research. This provides further support for adopting a theoretical based approach to examining the RAE, and a wider appreciation of the extent to which the contextual factors and social agents impact upon the prevalence of the RAE. Furthermore, it proposes potential implications with regard to the learning capabilities and more specifically information processing, which in turn would have implications for the prevalence of the RAE in relation to talent development and identification programs within sporting contexts (Pena-Gonzalez et al., 2018). Key attributes that influence selection within the current context include decision-making, technical proficiency, and game intelligence (e.g., cognition and spatial awareness); however, there is a paucity of research that has investigated such variables in association with the prevalence of the RAE. Huertas et al. (2019) however, examined the "cognitive function" of youth soccer players within two elite academies in relation to birth quartile. Despite the presence of the RAE, measures assessing players' cognitive function were comparable across birth quartiles (Huertas et al., 2019). Similar to existing RAE research in elite settings though, players' abilities (e.g., physical or cognitive measures) were shown to be comparable across birth quartiles, yet the RAE remained prevalent. As such, future research should seek to examine the pool of players from which the academy players are selected, as it appears that specific standards and expectations (imposed by social agents) are needed to reach the Academy level, yet the extent to which players from different birth quartiles meet these standards is disproportionate. Moreover, research examining the RAE in association with the talent identification and development processes has tended to adopt a reductionist approach, in which distinct characteristics associated with superior performance are assessed and analyzed in isolation (Unnithan et al., 2012). Consequently, research examining the RAE within sport should seek to assess beyond the physical and develop a wider appreciation of the RAE, ideally at the point at which grassroots-level participation leads into the Academy level (i.e., highly trained youth athletes). In doing so, future RAE research should also seek to develop an evaluative model, which begins to examine the synergy between key characteristics, associated with successful sporting performance.

The absence of physical performance data and perceptual–cognitive abilities is a limitation of the current study. In this regard, however, the purpose of the current study was to examine the extent of the RAE within a range of sports and across multiple age groups, in an internationally recognized multi-sport club that has a unique, overarching philosophy that emphasizes the technical, psychological, and perceptual–cognitive markers for talent identification, alongside the physical traits that are required for success at the elite level. In doing so, this research has demonstrated that, irrespective of the technical focus, the RAE is still present and is more prevalent within the younger age groups and in sports that are regarded as regionally popular (Hancock, 2020). Further investigations, however, are required to explore the relationships and differences in physical, perceptual–cognitive, and psychological characteristics, in association with the RAE. The implications of such research could provide insight for both talent development and talent identification processes, particularly within younger populations. Indeed, an improved understanding of the prevalence of the RAE within a given sporting context (FC Barcelona), which emphasizes the technical and perceptual–cognitive approach to talent identification, is likely to have wider implications for the meaning of the RAE for both talent identification and talent development in other sporting institutions, particularly those that adopt a similar approach. The difficulty in conducting such research, however, is developing a study design and data collection procedures that can obtain a holistic overview. Nevertheless, this identifies avenues for further research and highlights the need for an improved understanding toward the factors (and underpinning theories) influencing the RAE and, in particular aspects, beyond the physical. Consequently, research examining RAEs in sport should seek to explore the psychological (e.g., self-confidence, concentration, attention, and anxiety), perceptual–cognitive (e.g., decision-making, motor/technical skills, and game intelligence/awareness), and social (e.g., interaction between coaches, parents, and athletes) characteristics using an integrated approach (Figueiredo et al., 2019).

CONCLUSION

Results from this study demonstrate a persistent, but not universal, bias toward selecting individuals born early in the selection year, particularly within the younger age groups and in sports that are regarded as "high profile" (basketball and male soccer). Furthermore, the presence of the RAE diminished with increasing age, with smaller OR values evident within the senior squads. As a result, while there are numerous additional factors that require further investigation, the current results suggest that the popularity of sports in FC Barcelona affects the prevalence of the RAE. Indeed, application of the theoretical models proposed by Hancock et al. (2013) and Wattie et al. (2015) provides an improved framework for investigating the RAE within sporting contexts. The present results and context of the current study pose interesting questions regarding the factors that result in the presence of the RAE, within elite level sport. Indeed, due to the overarching club philosophy at FC Barcelona for superior psychological and perceptual–cognitive markers, the extent of the RAE might go beyond the previously researched physical dominance of those born earlier within the selection year. Nevertheless, further research should consider a greater array of the potential factors (i.e., social agents or theories, growth and maturation, physical prowess, and psychological and perceptual–cognitive markers) contributing to the prevalence of the RAE, and whether these alter across varying contexts (i.e., sport, age, playing level, and popularity).

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available because they were provided by the club in confidentiality.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee for Clinical Research of the Catalan Sports Council (17/2018/CEICEGC). Gatekeeper approval for the use of anonymised data was provided by FC Barcelona.

AUTHOR CONTRIBUTIONS

DM and FD were involved in collecting the necessary data. GD performed the data analysis and completed the initial draft of the manuscript. VU managed the project and aided in the analysis and development of the manuscript. All authors reviewed the paper prior to submission.

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REFERENCES

Augste, C., and Lames, M. (2011). The relative age effect and success in German elite U-17 soccer teams. *J. Sports Sci.* 29, 983–987. doi: 10.1080/02640414.2011.574719

Barbero-Alvarez, J. C., Soto, V. M., Barbero-Alvarez, V., and Granda-Vera, J. (2008). Match analysis and heart rate of futsal players during competition. *J. Sports Sci.* 26, 63–73. doi: 10.1080/02640410701287289

Bezuglov, E. N., Nikolaidis, P. T., Khaitin, V., Usmanova, E., Luibushkina, A., Repetiuk, A., et al. (2019). Prevalence of relative age effect in Russian soccer: the role of chronological age and performance. *Int. J. Environ. Res. Public Health* 16:4055. doi: 10.3390/ijerph16214055

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Esteva, S., Drobnic, F., Puigdellivol, J., Serratosa, L., and Chamorro, M. (2006). Fecha de nacimiento y éxito en el baloncesto profesional. *Apunts Medicina de l'Esport* 149, 25–30. doi: 10.1016/S1886-6581(06)70004-4

Figueiredo, A., Coelho-e-Silva, M., Cumming, S., and Malina, R. (2019). Relative age effect: characteristics of youth soccer players by birth quarter and subsequent playing status. *J. Sports Sci.* 37, 677–684. doi: 10.1080/02640414.2018.1522703

Figueiredo, A., Goncalves, C., Coelho-e-Silva, M., and Malina, R. (2009). Characteristics of youth soccer players who drop out, persist or move up. *J. Sports Sci.* 27, 883–891. doi: 10.1080/02640410902946469

Gyarmati, L., Kwak, H., and Rodriguez, P. (2014). "Searching for a unique style in soccer," in *KDD Workshop on Large-Scale Sports Analytics 2014* (New York, NW).

Hancock, D. (2020). "Antecedents and explanations of relative age effects," in *Relative Age Effects in Sport: International Perspective*, *1st Edn*, eds J. Dixon, A. Horton, L. Chittle, and J. Baker (New York, NW: Routledge). doi: 10.4324/9781003030737-3

Hancock, D., Adler, A., and Cote, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sports Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Helsen, W. F., van Winckel, J., and Williams, M. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Huertas, F., Ballester, R., Gines, H. J., Hamidi, A. K., Moratal, C., and Lupiáñez, J. (2019). Relative age effect in the sport environment. Role of physical fitness and cognitive function in youth soccer players. *Int. J. Environ. Res. Public Health* 16:2837. doi: 10.3390/ijerph16162837

Ibañez, S. J., Mazo, A., Nascimento, J., and Garcia-Rubio, J. (2018). The relative age effect in under-18 basketball: effects on performance according to playing position. *PLoS ONE* 13:e0200408. doi: 10.1371/journal.pone.0200408

Jeronimus, B., Stavrakakis, N., Veenstra, R., and Oldehinkel, A. (2015). Relative age effects in Dutch adolescents: concurrent prospective analysis. *PLoS ONE* 10:e0128856. doi: 10.1371/journal.pone.0128856

Larkin, P., and O'Connor, D. (2017). Talent identification and recruitment in youth soccer: recruiter's perceptions of the key attributes for player recruitment. *PLoS ONE* 12:e0175716. doi: 10.1371/journal.pone.0175716

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in English lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS ONE* 10:e0137238. doi: 10.1371/journal.pone.0137238

Malina, R. M., Figueiredo, A. J., and Coelho-e-Silva, M. J. (2017). Body size of male youth soccer players: 1978-2015. *Sports Med.* 47, 1983–1992. doi: 10.1007/s40279-017-0743-x

Mallo, J. (2020). *Team Sports Training: The Complexity Model.* London: Routledge. doi: 10.4324/9781003020141

Pena-Gonzalez, I., Fernandez-Fernandez, J., Moya-Ramon, M., and Cervello, E. (2018). Relative age effect, biological maturation, and coaches' efficacy expectations in young male soccer players. *Res. Q. Exerc. Sport* 89, 373–379. doi: 10.1080/02701367.2018.1486003

Povoas, S., Seabra, A., Ascensao, A., Magalhaes, J., Soares, J., and Rebelo, A. (2012). Physical and physiological demands of elite team handball. *J. Strength Cond. Res.* 26, 3365–3375. doi: 10.1519/JSC.0b013e318248aeee

Sallett, P., Perrier, D., Ferret, J., Vitelli, V., and Baverel, G. (2005). Physiological differences in professional basketball players as a function of playing position and level of play. *J. Sports Med. Phys. Fit* 45, 291–294.

Smith, L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Statista (2018). *Number of Births in Spain 2015 and 2016, by Month*. Available online at: https://www.statista.com/statistics/449593/number-of-births-in-spain-by-month/ (accessed April 20, 2018).

Unnithan, V., White, J., Georgiou, A., Iga, J., and Drust, B. (2012). Talent identification in youth soccer. *J. Sports Sci.* 30, 1719–1726. doi: 10.1080/02640414.2012.731515

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

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Female Youth Soccer Participation and Continued Engagement: Associations With Community Size, Community Density, and Relative Age

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Environmental context can impact youth engagement in sport and athlete development. Previous work has examined the population size of the birthplace of elite athletes; commonly known as the *birthplace* or *community size effect*. Community density has also been recognized as an important variable. Exact estimates for the ideal community characteristics and a thorough understanding of the underlying mechanisms has been somewhat elusive. Existing studies are cross-sectional in nature and there is evidence to suggest that significant variation exists within imposed categories. An athlete's birthdate position in a similar-age cohort can also impact development and has been associated with (dis)advantages resulting from subtle age differences (i.e., the relative age effect); it remains unknown if this variable is associated with population density. The objective of this study was to establish longitudinal participation trends among female youth soccer players in Ontario Canada, with consideration of community size, community density, and relative age. Within-category variation and associations between the variables were assessed. Registration entries at age 10 years ($n = 9,826$) and 16 years ($n = 2,305$) were isolated for analysis. Odds ratio analyses were conducted within each community size and density category for all 10 year old registrants; 95% confidence intervals were obtained. This procedure was repeated for all registrants at 16 years of age using the expected distribution at age 10 years to examine continued engagement. Findings suggest medium-sized communities (i.e., 10,000–249,999 inhabitants) provide the best odds of participation and continued engagement. Less densely populated communities (i.e., 50–<400 population/km^2) appeared to be ideal for facilitating participation at age 10 years, but not for engagement at age 16 years. However, within-category variation was evident when each community was inspected individually. Consistent with previous attempts to find an association between community size and the relative age effect, there did not appear to be an association between community density and birth quartile distribution. Observations from this study show that community size and community density are truly unique and separate variables. Future studies should consider the underlying contributions to both low and high participation and continued engagement, while being mindful of within-category variation.

Keywords: community size, community density, birthplace, relative age, youth sport, sport participation, athlete development, environment

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INTRODUCTION

Athletic development pathways are multifaceted and successful achievement of elite status is difficult to predict. A variety of direct (e.g., genetics) and indirect factors (e.g., opportunities for skilled instruction, location) can interact to enhance or constrain athletic potential (see Baker and Horton, 2004 for a review). Environmental context is one consideration when examining factors that can impact youth engagement in sport and athlete development, and consequently "where" an athlete is born has been recognized as an indirect contributor to athlete development (Côté et al., 2006). This "community size (CS) effect" (Baker et al., 2014) has traditionally focused on the birthplace size of professional athletes, using the location of birth as a proxy for early athlete development. For instance, Curtis and Birch (1987) produced one of the first studies to suggest the potential existence of a birthplace effect in professional and Olympic hockey players from Canada and the U.S.A. They found that the largest cities (>500,000) and rural communities (<1,000) were underrepresented as birthplaces of elite ice hockey players. Similar observations were reported for elite ice hockey players in North America (Côté et al., 2006) as well as other sports at the professional level, including basketball (Côté et al., 2006), baseball (Côté et al., 2006), football (MacDonald et al., 2009a), and golf (Côté et al., 2006; MacDonald et al., 2009b). However, the consistency of these estimates may be somewhat misleading as significant heterogeneity within similar-sized communities has been reported among Canadian National Hockey League draftees from different regions (Wattie et al., 2018; Farah et al., 2019).

Results in other parts of the world have also suggested inconsistency for CS effects; even when cultural context is controlled. For example, Baker et al. (2009b) examined the German first leagues of four sports: soccer, basketball, handball, and volleyball. While there was some evidence that communities with very small or very large populations were less likely to produce elite athletes, exceptions also occurred across the sport contexts examined. Similarly, Lidor et al. found variable "birthplace effects" among male (Lidor et al., 2010) and female athletes (Lidor et al., 2014) from several "Division I" sports in Israel. No consistent trends were identified between the two samples in any sport or population category, with the exception of elite volleyball players originating from very small communities (<2,000). Wattie et al. (2018) suggest that the inconsistencies may be attributable to broader social, political, and cultural factors both between and within countries.

The impact of CS may lie in the availability of early sport experiences. Very small, rural communities may lack facilities (e.g., ice rinks, soccer fields) and associated resources, as well as the human capital (e.g., coaches, participants, volunteers) to sustain organized leagues. Conversely, very large cities may suffer from insufficient availability of facilities and resources, leading to competition for access among community members. Indeed, several studies have shown that small to medium-sized communities (i.e., cities or towns that provide a balance between resources and demand) provide superior opportunities for young athletes in terms of participation at developmental levels, in additional to the likelihood of becoming an elite/professional athlete (e.g., Curtis and Birch, 1987). Turnnidge et al. (2014) reported higher rates of youth ice hockey participation in smaller cities (<100,000) within Ontario, Canada (male, age 8–16 years) as compared to larger communities (>100,000). Imtiaz et al. (2014) found CS was also related to longer-term participation in the same sport context in the only existing longitudinal study to date. Engagement rates of youth ice hockey players over a 7 year period (male, age 7–14 years) revealed a negative correlation with city size, with athletes from large cities (>500,000 inhabitants) being almost three times more likely to drop out of the sport during the examined timeframe.

To date, the aforementioned participation trends in youth sport do not explain the production of elite athletes with respect to CS. Rossing et al. (2016) found that elite football and handball athletes were generally more likely to come from communities with >30,000 inhabitants, despite a higher likelihood of participation among youth football and handball players in smaller communities (<30,000). However, additional examinations of both variables (i.e., youth participation and the associated likelihood of becoming an elite athlete) within other sports and cultural contexts are required before reliable conclusions can be made.

Recent studies have also suggested that community density (CD) should be considered along with CS; use of CD to evaluate athletic development contexts was first suggested in Baker et al. (2009b). Community density considers the number of people living within a specific unit of area, typically by square kilometer and may be a better indicator of the number of people drawing on available sport resources within a community. Hancock et al. (2018) examined the location of development by CS and CD for 4,062 elite, Portuguese volleyball players. While medium-sized cities (200,000–399,999 inhabitants) provided the best odds of reaching elite status in volleyball for both male and female athletes, the most elite "first-league" male players were found to come from less-densely populated areas. This trend was possibly facilitated by the availability and safe use of sport resources during development, and / or provision of a social structure that promoted athletic expertise (Hancock et al., 2018). No comparable findings were reported for females. Finnegan et al. (2017) also associated a greater likelihood of selection to talent development programs with a lower population density in a study of a study of elite youth Irish footballers.

Rossing et al. (2018) examined the developmental locations of elite and national football and handball players in Denmark, along with community-level youth as a comparison group. Odds ratio analyses suggested some inconsistencies in the optimal community size and density for athlete development in different sports (i.e., football vs. handball). However, a trend toward larger, more densely populated cities was found for elite (>30,000 inhabitants; >250 people/km^2) and national (>50,000 inhabitants; ≥1,000 people/km^2) football players, while mid-sized communities appeared to be best for the development of elite (between 30,000 and 100,000 inhabitants; 250–1,000 people/km^2) and national (between 30,000 and 50,000 inhabitants; no optimal population density identified) handball athletes. Similarly, Farah et al. (2018) found a positive relationship between population density and National Hockey

League draftees in all provincial regions of Canada; while also reporting significant heterogeneity when the origin of the same population of athletes ($n = 1,502$) was analyzed by CS (Farah et al., 2019). It has yet to be determined whether inclusion of the population density variable helps to explain the inconsistencies in CS research; however, it is evident that both overall size and CD should be included in future studies.

An additional indirect influence on athlete development is *date of birth* or more specifically, the athlete's birthdate position within a similar-age cohort. Generally, a birthdate closer to, but following an organizational cut-off date is associated with a sport advantage, and vice versa. The potential (dis)advantage resulting from these subtle age differences among peers grouped within the same cohort is known as the *relative age effect* (RAE) (Barnsley et al., 1985; Musch and Grondin, 2001; Wattie et al., 2008). The RAE is considered to be present when an over-representation of relatively older athletes is observed among the participant population of a particular sport, especially in competitive contexts where selection processes determine which athletes have opportunities to engage in competition (Cobley et al., 2009; Smith et al., 2018).

Relative age can potentially bias the athlete experience throughout the developmental years and ultimately influence attainment at the professional level (Côté et al., 2006; Bruner et al., 2011; Rossing et al., 2016). For example, the RAE can impact an athlete's exposure to sport in early childhood; studies have suggested that parents may be hesitant to register later-born, potentially smaller children in physical sports, such as soccer (Delorme et al., 2010) and ice hockey (Hancock et al., 2013; Smith and Weir, 2013), as inferred by lower registration numbers for the relatively youngest at the introductory levels of sport. The RAE is also believed to increase the likelihood that the relatively older—individuals who are more physically and psychologically mature due to greater accumulated life experience—will be selected to elite levels of sport at stages involving selection processes, where they will have access to higher quality training, coaching, and competition (Helsen et al., 1998; Musch and Grondin, 2001). This increased access to development opportunities can theoretically enhance the likelihood of reaching elite or professional status for the relatively oldest (Cobley et al., 2009); conversely, the relatively youngest may be at greater risk for negative sport experiences, leading to decreased competence and a decline in sport participation altogether (Barnsley and Thompson, 1988; Helsen et al., 1998; Delorme et al., 2010; Lemez et al., 2014).

The impact of CS has been examined in combination with relative age in several studies (e.g., Côté et al., 2006; Baker and Logan, 2007; Bruner et al., 2011; Turnnidge et al., 2014). To date, the published literature has shown no association between the two variables despite their potential influence on early sport experiences. Examinations of CD and the RAE are less common. Yet, competition for a position on a team has been identified as an important factor for the RAE to emerge (Musch and Grondin, 2001; Baker et al., 2009a) and thus, a high population density may predispose athletes in communities with greater competition for resources and playing positions (i.e., due to a high CD) to experience a greater risk of RAEs in youth sport. Preliminary evidence for the impact of CD on RAEs was reported by Finnegan et al. (2017); the strongest effect size for the RAE among the youth Irish footballers was observed in the most densely populated Irish province of Leinster. However, no test of the association between the two variables was conducted.

To further examine the impact of CS and CD in the realm of sport and associations with the RAE, the current study analyzed female youth soccer participation in the province of Ontario, Canada to establish longitudinal trends at the developmental level. Community size and density were examined at the category level to establish the likelihood of being a participant and subsequently remaining engaged in youth soccer across the pre- to post-adolescent transition years. Within-category variation and associations between CD and CS, and CD and the RAE were assessed to further expand current knowledge in this area and direct future research. In consideration of previous research findings, it was hypothesized that medium-sized communities with low-density populations would exhibit a greater likelihood of participation and continued engagement across the longitudinal period; but within-category variation would be observed similar to findings in other Canadian contexts (Wattie et al., 2018; Farah et al., 2019).

MATERIALS AND METHODS

A 1 year cohort of female[1] soccer participants was identified and an anonymized dataset was created by the provincial-level governing body for developmental[2] soccer, *Ontario Soccer* ($n = 9,915$). Registration entries were tracked over a 7 year period (i.e., age 10 to 16 years). Prior to analysis, the dataset was screened for inconsistent and/or missing information with respect to birth month. Each participant was coded by birth quartile based on the December 31st cut-off employed by Ontario Soccer for age groupings (i.e., Quartile 1 [Q1]: January through March; Quartile 2 [Q2]: April through June; Quartile 3 [Q3]: July through September; Quartile 4 [Q4]: October through December); consistent with previous research (e.g., Weir et al., 2010; Smith and Weir, 2013).

Longitude and latitude for each participant's home address were obtained using the *Google Maps Geocoding* platform. Missing or problematic postal codes were confirmed using alternate entries for the participant when available, or the entry was removed. Postal codes from outside of the province of Ontario were excluded (i.e., Michigan and Quebec). Community size (CS; overall number of inhabitants) and community density (CD; number of people per km^2) were obtained at the census

[1]Female samples have been under-represented in relative age research (Cobley et al., 2009). Likewise, the existing youth participation (vs. CS) studies have examined male athletes (Imtiaz et al., 2014; Turnnidge et al., 2014). Thus, a female sample was selected to address this imbalance and document participation trends in a popular youth sport context in Ontario, Canada.

[2]The term "developmental" refers to an individual who is in the process of growth or progress in his / her athletic skill development at non-professional levels (Smith and Weir, 2013).

subdivision level[3]. Registration entries at age 10 years (n = 9,826) and 16 years (n = 2,305) of age were isolated for analysis, representing the pre- to post-adolescence transition years for this female cohort.

To compare participation rates in Ontario by CS and CD, the expected distribution (based on the population distribution within the province of Ontario) was compared to the observed distribution of female soccer players at age 10 years. The 2011 Canadian Census profile was selected because it was the closest available population count to the baseline year of participation under examination (i.e., 2010). Nine CS categories were applied; consistent with previous research (e.g., Baker and Logan, 2007; Baker et al., 2009b; Wattie et al., 2018). These categories are as follows: (1) <2,500; (2) 2,500–4,999; (3) 5,000–9,999; (4) 10,000–29,999; (5) 30,000–99,999; (6) 100,000–249,999; (7) 250,000–499,999; (8) 500,000–999,999; (9) >1,000,000.

No known breakdown could be obtained from research conducted within North America for CD; although one such breakdown was available for a European country (see Rossing et al., 2016). Thus, a categorization system was developed based on the actual densities found within Ontario and the overarching objective of providing a detailed analysis of CD within the province. The eight CD categories are as follows: (1) <50 people/km^2; (2) 50–<200; (3) 200–<400[4]; (4) 400-<1,000; (5) 1,000–<1,500; (6) 1,500–<2,000; (7) 2,000–2,500; (8) =4,149.5 (i.e., Toronto). Odds ratio analyses were conducted for each category for all 10 year old, female registrants across the province; 95% confidence intervals were obtained and used to indicate statistical significance. This procedure was repeated for all registrants at 16 years of age using the expected distribution at age 10 years (to avoid bias) to examine continued engagement into the post-adolescent years. Finally, the procedure was applied for each individual community by CS for census subdivisions with a population >10,000[5] to ascertain the presence or absence of within-category variation and identify "hot spots" for maintaining engagement in developmental soccer. These community-level ORs were then descriptively examined vs. community density to ascertain whether this variable might explain within-category variation (if present).

To examine the association between relative age and CD, a four (birth quartiles) by eight (CD categories) chi-square analysis[6] was conducted using IBM SPSS Statistics 25. This procedure is consistent with Turnnidge et al. (2014).

[3]Census subdivision (CSD) refers to a municipality (as determined by provincial/territorial legislation) or areas treated as municipal equivalents for statistical purposes (e.g., Indian reserves, Indian settlements and unorganized territories; Statistics Canada, 2016). The CSD level is also associated with funding and maintenance of recreational facilities by local municipalities out of the property tax base (personal communication with G. Morin, September 25, 2017).

[4]A density of 400 or more people/km^2 is used as a threshold to distinguish between rural areas and population centers (Statistics Canada, 2017).

[5]Sample sizes for participants in communities of less than 10,000 inhabitants were considered to be too small within this one-year cohort and therefore, community level ORs were not calculated.

[6]A two-way chi-square is a test of association and not a test of interactions among variables.

RESULTS

General Findings—Community Size (Age 10 and 16 Years)

The overarching purpose of this study was to examine the likelihood of participation in female developmental soccer with respect to community size (CS) and community density (CD) within Ontario. The odds ratios (ORs) and 95% confidence intervals (CIs) by CS category are presented in **Table 1** (i.e., 2010 participation compared to the general population) and **Table 2** (i.e., 2016 participation compared to the expected population from 2010). At the 10 year age mark within this female cohort, mid-sized communities with population size categories ranging from 10,000 to 249,999 were found to have a greater likelihood of participation based on the overall number of inhabitants (ORs ranging from 1.31 to 1.56); while very small (<4,999; ORs ranging from 0.47 to 0.63) and very large (>1 million; OR 0.44) were observed to have a decreased likelihood of participation.

Communities ranging from 250,000 to 499,999 deviated from the general trend with low observed ORs for participation (OR 0.63). However, at age 16 years, this CS category maintained the highest likelihood of continued engagement (OR 1.29). Other community size categories were unremarkable in terms of keeping participants engaged at 16 years of age (i.e., ORs ∼1), with the exception of very large communities greater than one million people (OR 0.77).

General Findings—Community Density (Age 10 and 16 Years)

Community density revealed a slightly different pattern of association with participation and engagement into post-adolescence. The odds ratios (ORs) and 95% confidence intervals (CIs) by CD category are presented in **Tables 3**, **4**. At age 10 years, communities with a CD of 50 to <400 population/km^2 (i.e., two of the less densely populated categories in the analysis) appeared to be optimal for enhancing participation (ORs ∼1.5), while participation in larger communities (i.e., 2,000 to <2,500 population/km^2) and the largest community (i.e., Toronto) appeared to suffer (ORs of 0.85 and 0.44, respectively).

With respect to the association of CD with continued engagement at 16 years of age, communities with populations of 200 to <1,500 population/km^2 appeared to be optimal (ORs ranging from 1.12 to 1.15); while very small (<50 population/km^2; OR 0.84) and very large (4149.5 population/km^2; OR 0.77) had an increased risk of sport dropout.

Within-Category Variation by Community Size

To further investigate the impact of CS, ORs were calculated for all individual census subdivisions (i.e., "communities") >10,000 inhabitants. Within the three categories that had greater than expected participation rates (i.e., significant ORs in communities of 10,000–249,999 people), community-level ORs varied considerably with greater-, neutral, and lower-than expected participation rates in each of the three categories. Odds ratios ranged from 0.08 to 4.03 in the 10,000–29,999 category;

TABLE 1 | Odds ratios and 95% confidence intervals: Participation in 2010 compared to the general population in Ontario by community size (CS).

CS category	Province of Ontario		Ontario soccer 2010		Odds ratio	95% confidence intervals	
	Total population	%	Total participants	%		Lower	Upper
<2,500	180,952	1.41%	66	0.67%	**0.47**	0.23	0.72
2,500–4,999	219,575	1.71%	106	1.08%	**0.63**	0.44	0.82
5,000–9,999	617,113	4.80%	434	4.42%	0.92	0.82	1.01
10,000–29,999	1,424,976	11.09%	1,412	14.37%	**1.35**	1.29	1.40
30,000–99,999	1,830,277	14.24%	2,019	20.55%	**1.56**	1.51	1.61
100,000–249,999	2,366,327	18.41%	2,241	22.81%	**1.31**	1.26	1.36
250,000–499,999	956,161	7.44%	472	4.80%	**0.63**	0.54	0.72
500,000–999,999	2,640,694	20.55%	2,082	21.19%	1.04	0.99	1.09
>1,000,000	2,615,060	20.35%	994	10.12%	**0.44**	0.38	0.51
Total	12,851,135		9,826				

Bolded text indicates a significant odds ratio.

TABLE 2 | Odds ratios and 95% confidence intervals: Participation in 2016 compared to 2010 by community size (CS).

CS category	Ontario soccer 2010		Ontario soccer 2016		Odds Ratio	95% confidence intervals	
	Total participants	%	Total participants	%		Lower	Upper
<2,500	66	0.67%	8	0.35%	0.52	0	1.25
2,500–4,999	106	1.08%	23	1.00%	0.92	0.47	1.38
5,000–9,999	434	4.42%	92	3.99%	0.90	0.67	1.13
10,000–29,999	1,412	14.37%	319	13.84%	0.96	0.83	1.09
30,000–99,999	2,019	20.55%	516	22.39%	**1.12**	1.01	1.22
100,000–249,999	2,241	22.81%	521	22.60%	0.99	0.88	1.09
250,000–499,999	472	4.80%	141	6.12%	**1.29**	1.10	1.48
500,000–999,999	2,082	21.19%	502	21.78%	1.04	0.93	1.14
>1,000,000	994	10.12%	183	7.94%	**0.77**	0.60	0.93
Total	9,826		2,305				

Bolded text indicates a significant odds ratio.

TABLE 3 | Odds ratios and 95% confidence intervals: Participation in 2010 compared to the general population in Ontario by community density (CD).

CD category (Population/km^2)	Province of Ontario		Ontario soccer 2010		Odds ratio	95% confidence intervals	
	Total population	%	Total participants	%		Lower	Upper
<50	1,989,273	15.48%	1,498	15.25%	0.98	0.93	1.04
50–<200	971,559	7.56%	1,097	11.16%	**1.54**	1.47	1.60
200–<400	1,661,603	12.93%	1,822	18.54%	**1.53**	1.48	1.58
400–<1,000	1,618,015	12.59%	1,267	12.89%	1.03	0.97	1.09
1,000–<1,500	1,901,533	14.80%	1,674	17.04%	**1.18**	1.13	1.23
1,500–<2,000	1,300,671	10.12%	954	9.71%	0.95	0.89	1.02
2,000–<2,500	793,421	6.17%	520	5.29%	**0.85**	0.76	0.94
4149.5	2,615,060	20.35%	994	10.12%	**0.44**	0.38	0.51
Total	12,851,135		9,826				

Bolded text indicates a significant odds ratio.

TABLE 4 | Odds ratios and 95% confidence intervals: Participation in 2016 compared to 2010 by community density (CD).

CD category (Population/km^2)	Ontario soccer 2010		Ontario soccer 2016		Odds ratio	95% Confidence intervals	
	Total population	%	Total participants	%		Lower	Upper
<50	1,498	15.25%	304	13.19%	**0.84**	0.71	0.98
50–<200	1,097	11.16%	240	10.41%	0.92	0.78	1.07
200–<400	1,822	18.54%	477	20.69%	**1.15**	1.04	1.26
400–<1,000	1,267	12.89%	331	14.36%	**1.13**	1.00	1.26
1,000–<1,500	1,674	17.04%	432	18.74%	**1.12**	1.01	1.24
1,500–<2,000	954	9.71%	204	8.85%	0.90	0.75	1.06
2,000–<2,500	520	5.29%	134	5.81%	1.10	0.91	1.30
4149.5	994	10.12%	183	7.94%	**0.77**	0.60	0.93
Total	9,826		2,305				

Bolded text indicates a significant odds ratio.

TABLE 5 | Community density variation within community size and (lack of) correlation with the odds of participation.

CS category	Number of communities	Descriptive statistics—community density (Population/km^2)			Correlation between odds of participation and community density
		Mean	Standard deviation	Range	
<2,500	247	45.58	112.33	0.01–728.32	N/A
2,500–4,999	62	37.88	138.55	0.02–865.31	N/A
5,000–9,999	85	140.66	280.26	0.02–1148.87	N/A
10,000–29,999	87	170.61	316.00	7.10–1791.62	−0.06
30,000–99,999	32	503.64	538.83	14.49–2086.30	0.08
100,000–249,999	16	1060.60	600.24	42.18–1838.04	0.02
250,000–499,999	3	1114.64	279.31	870.61–1419.28	0.14
500,000–999,999	4	1297.26	1065.85	316.60–2439.93	−0.92
>1,000,000	1	N/A	N/A	N/A	N/A

Sample sizes for participants in communities of <10,000 inhabitants were considered to be too small within this 1-year cohort and therefore, community level ORs were not calculated and a correlation with community density is not available.

from 0.10 to 2.89 in the 30,000–99,999 category; and from 0.29 to 2.25 in the 100,000–249,999 category. Community density did not explain the variable ORs within CS categories (with one exception; see **Table 5**). As CS increased, CD became more variable within the CS category.

The deviation from the general trend was explored in the 250,000–499,999 category; ORs were variable as observed in other categories (ORs ranging from 0.33 to 1.10). Yet, the community[7] with the lowest odds of participation at the 10 year age mark (OR 0.33, 95% CIs 0.11, 0.55), also maintained the highest level of player engagement at age 16 years within this category (OR 1.97, 95% CIs 1.52, 2.42). It should also be noted that this particular category considered a lower number of communities due to the overall population distribution within Ontario, resulting in a smaller sample size vs. other community categories.

[7]The overall population size will not be provided to maintain the confidentiality of this community.

Relative Age and Community Density

There did not appear to be any association between birth quartile (representing relative age) and CD. Results of the four by eight chi-square analysis were not statistically significant, χ^2 (21, $n =$ 9,826) $= 14.876$, $p > 0.05$. Thus, there was a failure to reject the null hypothesis.

DISCUSSION

Overall Findings

The objective of this study was to examine the longitudinal participation trends in a female cohort of youth soccer players (age 10 to 16 years) in Ontario, Canada with consideration of community size (CS), community density (CD), and relative age (i.e., the RAE). Intra-category variation was assessed, and associations between these indirect contributors to athlete development were explored. In line with hypotheses, medium-sized CS categories ranging from 10,000 to 249,999 people were found to have the greatest likelihood of participation when compared to the population distribution in Ontario, while very small (<4,999) and very large (>1 million) had significantly lower participation than expected. Significant within-category variation was observed upon detailed examination of each respective community. The greatest likelihood of participation was associated with CD categories of 50–<400 people per square km (notably, defined as "rural" by Statistics Canada, 2017) at age 10 years; however, a shift toward increased odds of engagement in CD categories with mid-range densities was observed at age 16 years. There were no differences in birth quartile distribution with respect to CD, suggesting no association between these two variables.

Community Size

The favorable likelihood of participation observed in medium-sized community categories are somewhat consistent with previous findings for youth sport participation in Canada. However, the ideal CS for *female soccer* players appears to be slightly larger (i.e., between 10,000 and 249,999 inhabitants) than the favorable estimates for *male ice hockey* players (i.e., categories of <99,999 people; Turnnidge et al., 2014). Medium-sized communities may experience higher participation rates for a variety of reasons including greater access to club membership and facilities compared to larger communities, which may suffer from a population to resource imbalance (Curtis and Birch, 1987). Yet, medium-sized communities are still large enough to sustain organized leagues, which may be difficult in a rural community with a small population, especially if it is in a geographically remote location. The sport environment of larger cities might also be more competitive because there are more participants to accommodate; this could lead to an emphasis on performance and winning over enjoyment and personal development, which may have a negative impact on long-term sport participation (Weiss and Williams, 2004; Cervelló et al., 2007; Hancock and Côté, 2014). These findings are also likely to be consistent with the observed advantages of residing in medium-sized communities with respect to becoming an elite athlete. Although this variable was not assessed in this analysis, the availability of a larger pool of athletes can theoretically enhance the level of competition experienced during youth and consequently, facilitate athlete development in the long-run.

The likelihood of maintaining engagement at 16 years of age was not as closely tied to medium-sized communities as the participation rates originally observed at the age of 10 years. The ideal category based on OR analysis was 250,000–499,999 (OR 1.29, 95% CIs 1.10, 1.48); notably, a category that also had a lower likelihood of participation at 10 years of age (OR 0.63, 95% CIs 0.54, 0.72). This trend could possibly suggest that membership is not particularly inclusive, or that other options exist for organized sport in the community; but those who do maintain engagement with local soccer clubs have positive experiences. The 30,000–99,999 category also appeared to be advantageous (OR 1.12, 95% CIs 1.01, 1.22) in terms of maintaining engagement; while all other mid-sized categories hovered near an OR of 1.0, indicating engagement rates were aligned with the observed participation numbers at 10 years of age. Very small (<2,500 inhabitants[8]) and very large (>1 million inhabitants) had a low likelihood of maintaining engagement at 16 years of age. This finding of a low likelihood for continued engagement in the largest category differs from a previous longitudinal study in Ontario, Canada. Specifically, Imtiaz et al. (2014) found an OR of 2.88 (95% CIs 2.52, 3.29) for the largest category included in the study (i.e., >500,000 inhabitants). Notably, this category is not directly comparable to this study which employed a high endpoint of greater than one million people, which solely represented the city of Toronto, Ontario. Further, Imtiaz et al. examined male ice hockey players who likely develop under different organizational sport structures and cultural attitudes about participation in their respective sport in Canada.

The different categories employed in this line of research also highlight a recent criticism of community size research. The use of wide population categories can potentially hide meaningful variation within the categories themselves (Wattie et al., 2018). Indeed, this was the case when engagement rates for individual communities were examined and has also been observed for National Hockey League draftees across Canada (Farah et al., 2019). Underlying reasons for these findings are likely multifactorial and variable between regions. For instance, geographic location may impact participation in communities of comparable size (e.g., adverse climates in northern regions, proximity of neighboring communities for competition purposes and associated travel time); the characteristics of the clubs themselves may influence participation and continued engagement (e.g., an emphasis on inclusion, participation, and development vs. performance and winning); and decision-making at the municipal level determines allocation of funding and consequently, the number and type of facilities and programming that are available to residents. Farah et al. (2019) also suggested that socioeconomic contributors (e.g., affecting the affordability of organized sport) and ethnic diversity (e.g., affecting cultural importance of the sport within the community) may impact athletic pursuits and achievement.

Community Density

A high likelihood of participation was associated with less densely populated communities in Ontario at age 10 years, with the best odds of participation found in the categories of 50–<200 people/km^2 (OR 1.54, 95% CIs 1.47, 1.60) and 200–<400 people/km^2 (OR 1.53, 95% CIs 1.48, 1.58). Conversely, densely populated cities appeared to have a detrimental impact on participation as observed in the ORs for the 2,000–<2,500 people/km^2 category (OR 0.85, 95% CIs 0.76, 0.94) and 4,194.5 people/km^2 (OR 0.44, 95% CIs 0.38, 0.51). Comparisons to previous research are not available with respect to the impact of CD on participation, as studies incorporating this measure have focused on the development of elite athletes as opposed to overall participation at developmental levels. Advantages in less densely populated cities have been reported for Portuguese,

[8]The sample size may be too small to produce an accurate estimate for this category; as evidenced by the large confidence interval (see **Table 2**). The OR should be interpreted with caution.

male volleyball players (but not for females; Hancock et al., 2018). However, inherent differences in the sport system, geography, population distribution, and other potentially relevant factors make comparisons difficult between North American and European contexts. Specific to the Canadian context, Farah et al. (2018) reported an increased likelihood of being drafted into the National Hockey League for athletes from communities with higher population densities; but, the focus of the current study was on participation and continued engagement vs. athlete achievement.

Mid-range categories appeared to be best for maintaining engagement at age 16 years and thus, might be hypothesized to be the best environment for producing elite female soccer players as the development of expertise requires ongoing opportunities for competition and training. However, the disparities between CD categories were somewhat diminished between the ages of 10 and 16 years suggesting a reduced impact of population density; and further research is needed to support this hypothesis. These findings do support the suggested mechanisms for the "birthplace effect." While less densely populated communities may offer greater opportunities for free play and organized participation during the earlier stages of athlete development, the benefits of this environmental context may diminish if these communities are not populated enough to provide the necessary resources for higher levels of training and skill development (e.g., sport facilities, coaches and competitors; Curtis and Birch, 1987; Côté et al., 2006). More specifically, this deviation in participation trends across the developmental years could suggest different advantages associated with different environmental contexts at different timepoints; possibly reconciling the current findings with Farah et al. (2018). This hypothesis is worthy of further investigation in future studies.

Consistent with previous attempts to find an association between CS and the RAE (Côté et al., 2006; Bruner et al., 2011; Turnnidge et al., 2014), there did not appear to be a relationship between CD and birth quartile distribution. While both CD and the RAE appear to be related to sport participation and ongoing engagement (or dropout), the relationship between the place of early development and the RAE is likely complicated and not easily isolated by the statistical methods used to date. Many variables can potentially influence athlete development (Baker and Horton, 2004) and this development does not occur in a vacuum; interactions between multiple systems of the developing individual are ongoing throughout the years of sport participation (Bronfenbrenner, 1977, 1995, 1999). For instance, the study of CS and CD falls within the "macrosystem" (i.e., cultural and social forces related to sport). However, the microsystem(s) (e.g., coach—athlete relationship), mesosystem(s) (e.g., coach—parent relationship), exosystem(s) (e.g., broader sport policies) and chronosystem(s) (e.g., change over time to personal characteristics or the environment) can all play a role in the developmental process.

Future Directions

In general, mechanisms of CS and CD are largely unknown and represent promising avenues of investigation (Hancock et al., 2018; Wattie et al., 2018). Future research in this sample population and others should investigate the contributions to both high and low participation and ongoing engagement, such as the number of/proximity to soccer facilities and open spaces for unorganized play; distances traveled both within (i.e., between home and club locations) and between neighboring communities (i.e., for competition between elite teams); the organizational structures and philosophies of local clubs (as recommended in Fraser-Thomas et al., 2010), and proximity to elite teams (Farah et al., 2018; Rossing et al., 2018). This type of research can inform strategies to increase participation at the local level. For instance, community officials and sport administrators can utilize current and future research to promote a sporting structure that enhances the self-concept of individual athletes. Consideration of more inclusive sport systems (e.g., reducing team selections, smaller teams to increase playing time) and a focus on creating a sense of team identity (e.g., establishing community support and recognition) would likely be beneficial (Hancock and Côté, 2014). The proxies of CS and CD should be considered simultaneously in future analyses as both variables have shown an association with participation rates, ongoing engagement, and the likelihood of becoming an elite athlete. Further, observations from this study show that CS and CD are truly unique and separate variables; one does not inform the other.

Strengths and Limitations

This study adds to current literature by providing a longitudinal analysis of female developmental soccer participation with consideration of both CS and CD. Community density has been observed to be an important variable in recent studies with respect to elite athlete development, and this study is one of the first to consider a relationship with sport participation at developmental levels. Soccer is currently the most popular sport among Canadian youth (Clark, 2008; Canadian Heritage, 2013) and thus, provided an ideal sport context for examination due to the high number of participants it attracts (sport selections made by Cobley et al., 2014 and Rossing et al., 2016 with a similar rationale) and its accessibility to the local community.

The use of postal codes, geocoding, and census subdivisions provided an objective, consistent method of coding for community location and characteristics; a limitation present, but rarely discussed in previous literature. Census subdivision is consistent with municipal funding structures that may impact sport programming and facility funding. However, it should be noted that it is still subject to limitations with respect to accounting for the proximity of neighboring communities (e.g., for competition purposes, options for club membership). Further, the proportion of youth in each community size category may vary and could potentially affect the accuracy of the calculated odds ratios. The use of home location (as opposed to club location) might be criticized for not providing an exact indicator of the community in which sport participation took place. However, participation rates at age 10 years were compared to the overall population distribution within the province, which are based on location of residence; thus, the use of club location could have introduced bias and home location was the best choice for this particular analysis. Future work will expand on trends for club location. Hometown was also used by Wattie et al.

(2018); and either measure is preferable to using an athlete's birthplace, which may suffer to a greater degree from geographic movement/migration and conceal effects for small communities that lack medical facilities for childbirth (Rossing et al., 2016).

The choice of CS and CD categories may affect the direction of findings in this line of research and important variation can be lost when large ranges are used (see discussion in Wattie et al., 2018). Community size categories for this study were selected to allow for comparisons with previous research; the majority of existing studies have employed a similar breakdown (e.g., Baker and Logan, 2007; Baker et al., 2009b; Wattie et al., 2018). The limitations of using these groupings in this particular study included unbalanced sample sizes at age 10 years (i.e., only three communities were included in the "250,000–499,999" category due to the population distribution in Ontario) and a very small sample size for rural communities at age 16 years. Community density categories were selected using guidelines from Statistics Canada and the actual population distributions in Ontario. However, there are no existing studies available for comparison within North America and European categories are not appropriate to use due to significant geographical differences between countries (Baker et al., 2009b; Wattie et al., 2018). Furthermore, generalization of the findings to other regions in Canada cannot be made as the population of Ontario disproportionately contributes to the national population distribution and significant variation is present between provinces (Wattie et al., 2018).

The cohort information examined in this study was collected retrospectively. Ideally, an examination of participant engagement would be conducted during the actual development process and include both male and female athletes of various ages; however, this was not logistically feasible when seeking to obtain a provincially representative sample from the provincial organization. Initial participation was measured at age 10 years and again at age 16 years, which provided a valuable analysis of the pre- to post-adolescent transition years; but it does not tell us about participants who started playing soccer in early childhood and dropped out prior to 10 years of age.

CONCLUSIONS

Community size and community density are both associated with female soccer participation in the province of Ontario, Canada. In general, mid-sized communities appear to provide the best odds of participation and continued engagement during the pre- to post-adolescent transition years; less densely populated communities also appear to be ideal. However, future studies should be mindful of within-category variation and region-to-region differences between communities of comparable size. Additional longitudinal examinations of youth sport participation are needed to confirm these findings and unravel the underlying mechanisms contributing to these effects.

DATA AVAILABILITY STATEMENT

The data analyzed in this study was obtained from Ontario Soccer. Access to the data is not available on ethical grounds as it contains personal information.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Office of the Research Ethics Board—University of Windsor. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KS and PW designed the analysis and edited the manuscript. KS performed the statistical analyses, summarized the results, and drafted the manuscript. Both authors have read and approved the final version of the manuscript.

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REFERENCES

Baker, J., and Horton, S. (2004). A review of primary and secondary influences on sport expertise. *High Abil. Stud.* 15, 211–228. doi: 10.1080/1359813042000314781

Baker, J., and Logan, A. J. (2007). Developmental contexts and sporting success: birth date and birthplace effects in national hockey league draftees 2000-2005. *Br. J. Sports Med.* 41, 515–517. doi: 10.1136/bjsm.2006.033977

Baker, J., Schorer, J., Cobley, S., Bräutigam, H., and Büsch, D. (2009a). Gender, depth of competition and relative age effects in team sports. *Asian J. Exerc. Sport Sci.* 6, 1–7.

Baker, J., Schorer, J., Cobley, S., Schimmer, G., and Wattie, N. (2009b). Circumstantial development and athletic excellence: the role of date of birth and birthplace. *Eur. J. Sport Sci.* 9, 329–339. doi: 10.1080/17461390902933812

Baker, J., Shuiskiy, K., and Schorer, J. (2014). Does size of one's community affect likelihood of being drafted into the NHL? Analysis of 25 years of data. *J. Sports Sci.* 32, 1570–1575. doi: 10.1080/02640414.2014.908319

Barnsley, R. H., and Thompson, A. H. (1988). Birth date and success in minor hockey: the key to the N.H.L. *Can. J. Behav. Sci.* 20, 167–176.

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *Am. Psychol.* 32:531.

Bronfenbrenner, U. (1995). "Developmental ecology through space and time: a future perspective," in *Examining Lives in Context: Perspectives on the Ecology of Human Development,* eds P. Moen, G. H. Elder Jr, and K. Lüscher (Washington, DC: American Psychological Association), 619–647.

Bronfenbrenner, U. (1999). "Environments in developmental perspective: theoretical and operational models," in *Measuring Environment Across the Life Span: Emerging Methods and Concepts,* eds S. L. Friedman and T. D. Wachs (Washington, DC: American Psychological Association), 3–28.

Bruner, M. W., MacDonald, D. J., Pickett, W., and Côté, J. (2011). Examination of birthplace and birthdate in world junior ice hockey players. *J. Sports Sci.* 29, 1337–1344. doi: 10.1080/02640414.2011.597419

Canadian Heritage (2013). Sport participation 2010. *Research Paper.* Available online at: http://publications.gc.ca/collections/collection_2013/pc-ch/CH24-1-2012-eng.pdf (accessed December 29, 2018).

Cervelló, E. M., Escartí, A., and Guzmán, J. F. (2007). Youth sport dropout from the achievement goal theory. *Psicotherma* 19, 65–71.

Clark, W. (2008). *Canadian Social Trends. Kids' Sport. Statistics Canada Catalogue (11-008-X).* Available online at: https://www150.statcan.gc.ca/n1/pub/11-008-x/2008001/article/10573-eng.pdf (accessed May 29, 2019).

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S., Hanratty, M., O'Connor, D., and Cotton, W. (2014). First club location and relative age as influences on being a professional Australian rugby league player. *Int. J. Sports Sci. Coach.* 9, 335–346. doi: 10.1260/1747-9541.9.2.335

Côté, J., MacDonald, D. J., Baker, J., and Abernethy, B. (2006). When "where" is more important than "when": birthplace and birthdate effects on the achievement of sporting expertise. *J. Sports Sci.* 24, 1065–1073. doi: 10.1080/02640410500432490

Curtis, J. E., and Birch, J. S. (1987). Size of community of origin and recruitment to professional and olympic hockey in North America. *Sociol. Sport J.* 4, 229–244. doi: 10.1123/ssj.4.3.229

Delorme, N., Boiché, J., and Raspaud, M. (2010). Relative age effects in female sport: a diachronic examination of soccer players. *Scand. J. Med. Sci. Sports* 20, 509–515. doi: 10.1111/j.1600-0838.2009.00979.x

Farah, L., Schorer, J., Baker, J., and Wattie, N. (2018). Population density and proximity to junior developmental teams affect the development of national hockey league draftees. *Scand. J. Med. Sci. Sports* 28, 2427–2435. doi: 10.1111/sms.13247

Farah, L., Schorer, J., Baker, J., and Wattie, N. (2019). Heterogeneity in community size effects: exploring variations in the production of national hockey league draftees between canadian cities. *Front. Psychol.* 9:e2746. doi: 10.3389/fpsyg.2018.02746

Finnegan, L., Richardson, D., Littlewood, M., and McArdle, J. (2017). The influence of date and place of birth on youth player selection to a national football association elite development programme. *Sci. Med. Football* 1, 30–39. doi: 10.1080/02640414.2016.1254807

Fraser-Thomas, J. L., Côté, J., and MacDonald, D. J. (2010). Community size in youth sport settings: examining developmental assets and sport withdrawal. *PHENex J.* 2, 1–9.

Hancock, D. J., and Côté, J. (2014). "Birth advantages, social agents, and talent development in youth sport" in *Positive Human Functioning From a Multidimensional Perspective: Promoting High Performance,* eds A. R. Gomes, R. Resende, and A. Albuquerque (New York, NY: Nova Publishers), 15–32.

Hancock, D. J., Coutinho, P., Côté, J., and Mesquita, I. (2018). Influences of population size and density on birthplace effects. *J. Sports Sci.* 36, 33–38. doi: 10.1080/02640414.2016.1276614

Hancock, D. J., Ste-Marie, D. M., and Young, B. W. (2013). Coach selections and the relative age effect in male youth ice hockey. *Res. Q. Exerc. Sport* 84, 126–130. doi: 10.1080/02701367.2013.762325

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *Am. J. Hum. Biol.* 10, 791–798.

Imtiaz, F., Hancock, D. J., Vierimaa, M., and Côté, J. (2014). Place of development and dropout in youth ice hockey. *Int. J. Sport Exerc. Psychol.* 12, 234–244. doi: 10.1080/1612197X.2014.880262

Lemez, S., Baker, J., Horton, S., Wattie, N., and Weir, P. (2014). Examining the relationship between relative age, competition level, and dropout rates in male youth ice-hockey players. *Scand. J. Med. Sci. Sports* 24, 935–942. doi: 10.1111/sms.12127

Lidor, R., Arnon, M., Maayan, Z., Gershon, T., and Côté, J. (2014). Relative age effect and birthplace effect in division 1 female ballgame players – the relevance of sport-specific factors. *Int. J. Sports Exerc. Psychol.* 12, 19–33. doi: 10.1080/1612197X.2012.756232

Lidor, R., Côté, J., Arnon, M., Zeev, A., and Cohen-Maoz, S. (2010). Relative age and birthplace effects in division I players – do they exist in a small country? *Talent Dev. Excel.* 2, 181–192.

MacDonald, D. J., Cheung, M., Côté, J., and Abernethy, B. (2009a). Place but not date of birth influences the development and emergence of athletic talent in American football. *J. Appl. Sport Psychol.* 21, 80–90. doi: 10.1080/10413200802541868

MacDonald, D. J., King, J., Côté, J., and Abernethy, B. (2009b). Birthplace effects on the development of female athletic talent. *J. Sci. Med. Sport* 12, 234–237. doi: 10.1016/j.jsams.2007.05.015

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Rossing, N. N., Nielsen, A. B., Elbe, A.-M., Karbing, D. S. (2016). The role of community in the development of elite handball football players in Denmark. *Eur. J. Sport Sci*. 16, 237–245. doi: 10.1080/17461391.2015.1009492

Rossing, N. N., Stentoft, D., Flattum, A., Côté, J., and Karbing, D. S. (2018). Influence of population size, density, and proximity to talent clubs on the likelihood of becoming an elite youth athlete. *Scand. J. Med. Sci. Sports* 28, 1304–1313. doi: 10.1111/sms.13009

Smith, K. L. (2019). *The role of relative age, community size, and positive youth development on female youth soccer participation* [Dissertation thesis]. University of Windsor, Windsor, ON, Canada.

Smith, K. L., and Weir, P. L. (2013). An examination of the relative age effect in developmental girls' hockey in Ontario. *High Abil. Stud.* 24, 171–184. doi: 10.1080/13598139.2013.847357

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Statistics Canada (2016). *Dictionary, Census of Population.* Available online at: https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo012-eng.cfm.

Statistics Canada (2017). *Dictionary, Census of Population.* Available online at: https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo049a-eng.cfm.

Turnnidge, J., Hancock, D. J., and Côté, J. (2014). The influence of birth date and place of development on youth sport participation. *Scand. J. Med. Sci. Sports* 24, 401–408. doi: 10.1111/sms.12002

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2018). Seeing the forest but not the trees: heterogeneity in community size effects in canadian ice hockey players. *J. Sports Sci.* 36, 436–444. doi: 10.1080/02640414.2017.1313444

Weir, P. L., Smith, K. L., Paterson, C., and Horton, S. (2010). Canadian women's ice hockey – evidence of a relative age effect. *Talent Dev. Excel.* 2, 209–217.

Weiss, M. R., and Williams, L. (2004). "The why of youth sport involvement: a developmental perspective on motivational processes," in *Developmental Sport and Exercise Psychology: A Lifespan Perspective,* eds M. R. Weiss (Morgantown, WV: Fitness Information Technology), 223–268.

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"Birthday-Banding" as a Strategy to Moderate the Relative Age Effect: A Case Study Into the England Squash Talent Pathway

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The relative age effect (RAE) is almost pervasive throughout youth sports, whereby relatively older athletes are consistently overrepresented compared to their relatively younger peers. Although researchers regularly cite the need for sports programs to incorporate strategies to moderate the RAE, organizational structures often continue to adopt a one-dimensional (bi)annual-age group approach. In an effort to combat this issue, England Squash implemented a "birthday-banding" strategy in its talent pathway, whereby young athletes move up to their next age group on their birthday, with the aim to remove particular selection time points and fixed chronological bandings. Thus, the purpose of this study was to examine the potential effects of the birthday-banding strategy on birth quarter (BQ) distributions throughout the England Squash talent pathway. Three mixed-gender groups were populated and analyzed: (a) ASPIRE athletes ($n = 250$), (b) Development and Potential athletes ($n = 52$), and (c) Senior team and Academy athletes ($n = 26$). Chi-square analysis and odds ratios were used to test BQ distributions against national norms and between quartiles, respectively. Results reveal no significant difference between BQ distributions within all three groups ($P > 0.05$). In contrast to most studies examining the RAE within athlete development settings, there appears to be no RAE throughout the England Squash talent pathway. These findings suggest that the birthday-banding strategy may be a useful tool to moderate RAE in youth sports.

Keywords: athlete development, talent development, talent identification, skill acquisition, expertise, RAE, youth sport, bio-banding

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INTRODUCTION

More than 20 million people across 185 countries regularly participate in squash (US Squash, 2019); thus, reaching the highest levels of performance can be extremely competitive. The aim of a talent pathway is to recruit young athletes with the prospect of advancing into experts at the senior professional level by providing them with the most appropriate learning environment to achieve their potential (Kelly et al., 2018). In an effort to fulfill this aim, sport organizations have emphasized the importance of identifying early predictors for long-term attainment so that the most highly talented youth athletes receive continued support from a young age

(Stratton et al., 2004). However, the complex nature of the talent development process suggests that the application of early predictors is often flawed and subject to selection biases (Baker et al., 2003).

One such bias is the influence of selection and progression through fixed annual birthdate distribution—known as the relative age effect (RAE; Barnsley et al., 1985). Research consistently highlights that youth athletes born earlier in the selection year relative to a predetermined cutoff date (e.g., September 1 to August 31) are often overrepresented within talent development pathways compared to those born later in the same selection year (Cobley et al., 2009). Indeed, the RAE is a global phenomenon, indicating that cultural factors (e.g., nationality, traditional preferences, socioeconomic circumstance) are potentially extraneous and are independent of specific cutoff dates (e.g., Helsen et al., 2005; Nakata and Sakamoto, 2013; Turnnidge et al., 2014; Cobley et al., 2018). In addition, the RAE is almost ubiquitous throughout talent development pathways in youth sport when (bi)annual age grouping is adopted although in certain sports it may be more prevalent (e.g., soccer) than others (gymnastics; Smith et al., 2018).

Although squash appears to be an unexplored sport among RAE literature, other racquet sports (e.g., badminton, table tennis, tennis) are consistent with the findings of an overrepresentation of players born in the first half of the year compared to their later born age group equivalents at the youth level (e.g., Ulbricht et al., 2015; Romann et al., 2018; Faber et al., 2020). For instance, previous studies document a skewed birthdate distribution in youth tennis, whereby a higher number of athletes involved in talent development programs were born in the first half of the selection year (e.g., values ranging from 60 to 86%) compared to the second half (Dudink, 1994; Filipcic, 2001; Edgar and O'Donoghue, 2005; Loffing et al., 2010). As an example, Ulbricht et al. (2015) find a similar trend throughout the German Tennis Federation male talent pathway (U12 to U18) with RAEs more prevalent at higher competition levels. For instance, more selected players were born in the first half of the year (compared with normative values) for national (70.2%) and regional (65.1%) players. Interestingly, they find little evidence to suggest an RAE in senior ranked representatives (56% born in the first half of the year). Thus, it is possible that, during the transition from the elite youth level to senior professional status, a greater number of relatively older athletes are more likely to drop out of talent pathways, which is also reported in various other sports (e.g., Cobley et al., 2008; Baker et al., 2010; Gil et al., 2020).

Sticking with the theme of racquet sports, Faber et al. (2019) found an RAE among French table tennis players aged 14–21 years. Similarly, during their investigation into the Swiss national talent development program, Romann et al. (2018) reveal that both tennis and badminton pathways had a pronounced RAE, again favoring those born in the first half of the year. Although the RAE is consistently found at youth levels, findings at senior levels are equivocal. For instance, Romann et al. (2018) and Faber et al. (2019) find no RAE among their senior tennis and table tennis cohorts, respectively. Correspondingly, Nakata and Sakamoto (2013) find no significant differences in the birth quartile distribution of their senior Japanese male badminton population. These conflicting findings underscore the importance of exploring the prevalence of RAEs at different stages of development.

It is evident that there is a complicated relationship between the month in which athletes are born, their opportunities to be selected into a talent pathway, and their likelihood of successfully transitioning from such a program (Kelly et al., 2020). Although there is an extensive body of RAE research over the last three decades, questions still remain concerning the organizational structures that underpin these relationships (Cobley et al., 2019). The need to examine these structures is emphasized by a growing body of literature exploring potential strategies for mitigating RAEs in youth sports programs (Romann and Cobley, 2015; Mann and van Ginneken, 2017; Cobley et al., 2019; Webdale et al., 2019). In order to gain a deeper understanding of the RAE, it is important to recognize that it represents a by-product of sports organizations' policies regarding grouping athletes by chronological age. Although such policies are often intended to promote developmentally appropriate levels of challenge and create fair competition, it is evident that these policies can have unintended consequences (Baxter-Jones, 1995). As such, it is worthwhile to explore the different types of grouping strategies that can be used within organizations as well as the potential implications of these strategies on athletes' developmental trajectories.

In an attempt to combat the RAE due to a fixed chronological age group approach, England Squash implemented a *birthday-banding* strategy within their talent pathway 7 years ago. Birthday-banding refers to the organizational policy whereby young athletes move up to their next birthdate group on their birthday with the aim of removing particular selection time points and fixed chronological age groups. As an example, a U13 player would move up to the U14 age group on their birthday and remain in that age group until their following birthday. As such, recruitment remains continual to ensure there is an equal opportunity for all players to be selected during the entire selection year. Although this strategy has been implemented in practice, the relation between the birthday-banding strategy and birth quartile distributions has yet to be empirically evaluated. Thus, the aim of this study is to examine birth quartile distributions against normative values within the England Squash talent pathway. Drawing upon existing literature in racquet sports, it was hypothesized that there would be an RAE within the youth cohorts but not among the adult cohorts.

METHODS

Sample and Design

A combined total of 328 participants (male = 188, female = 126) from the England Squash talent pathway are included in this study. Following two grassroots entry levels (schools and clubs and county programs and local academies), the talent pathway comprises five selection levels within a progressive structure (see **Figure 1**): (a) ASPIRE ($n = 250$; $M_{\text{age}} = 13.9 \pm 2.1$ years; male = 157, female = 93), (b) Potential ($n = 27$; $M_{\text{age}} = 13.5 \pm 1.4$

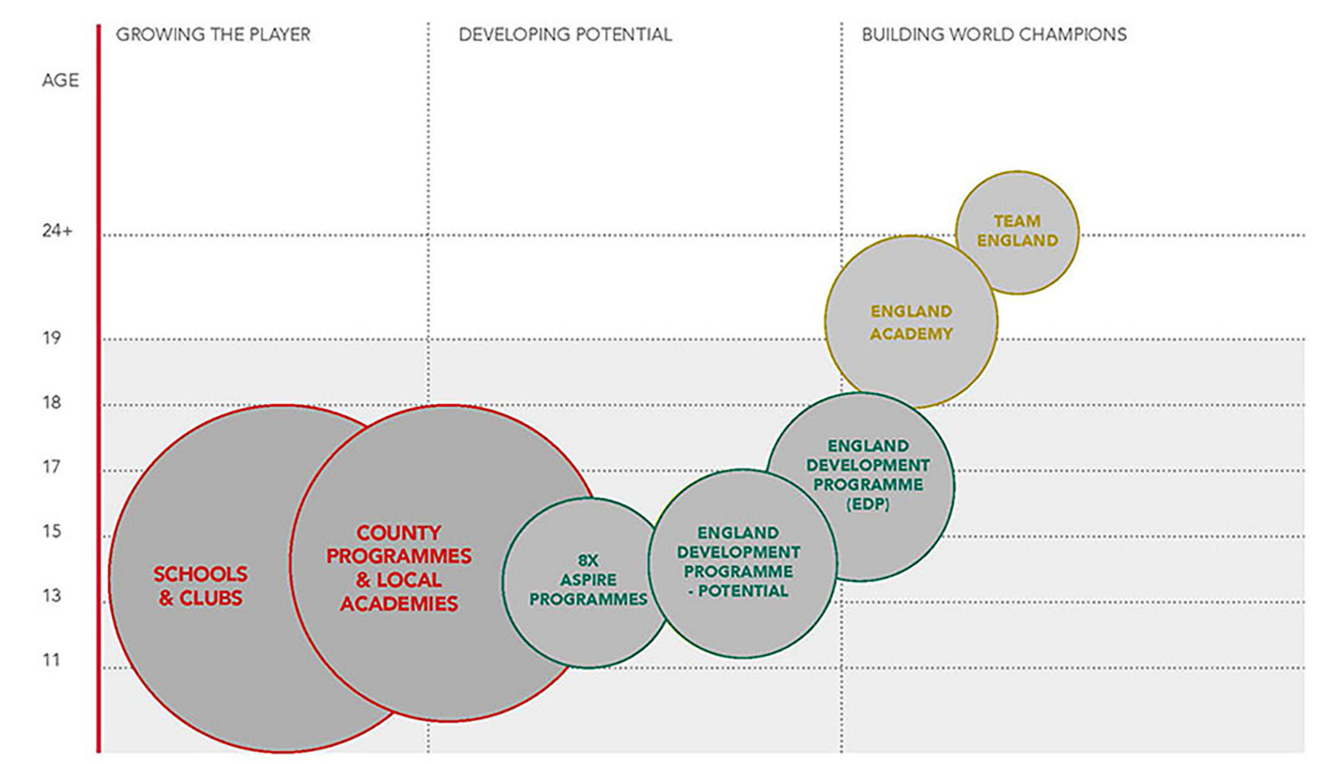

FIGURE 1 | The England Squash talent pathway.

years; male = 14, female = 13), (c) Development ($n = 26$; $M_{age} = 17.1 \pm 1.3$ years; male = 15, female = 10), (d) Academy ($n = 12$; $M_{age} = 20.1 \pm 2.3$ years; male = 8, female = 4), and (e) Senior team ($n = 14$; $M_{age} = 29.8 \pm 4.3$ years; male = 8, female = 6). ASPIRE acts as the first stepping-stone onto the England Squash talent pathway, which offers the most promising young players an environment to develop within each English region. This leads into the Potential cohort, which is focused on providing the first national-level squad for the younger and developing talent in the country. This develops and feeds the pool of players for the Development cohort, which is for those who wish to continue their progression in the sport to a world-class level toward the Academy and Senior team (England Squash, 2020).

Training time varies across the five selection levels: (a) ASPIRE = 3–6 h/week; (b) Potential = 5–10 h/week; (c) Development = 7–14 h/week; (d) Academy = 15–20 h/week; and (e) Senior team = 15–20 h/week. To create a more accurate representation of participation in the pathway and because the sample sizes are limited, ASPIRE athletes were analyzed on their own, and Development and Potential ($n = 53$) and Senior team and Academy ($n = 26$) are grouped together for analysis to create three cohorts. Because mixed-gender training and competition is common practice throughout the England Squash talent pathway (and because the sample sizes are limited), male and female athletes were analyzed together within the three cohorts. To offer a comparison between genders, the male and female combined cohorts were also analyzed. This study received ethical approval from the lead author's institution.

Procedures

The 12 months of the year were divided into four birth quarters (BQs), conforming to the strategy used to examine the RAE in other UK populated studies (e.g., Helsen et al., 2005). In line with the chronological age grouping system applied in the UK, September was classified as *month 1* descending to August as *month 12*. To conform with previous studies of a similar design (e.g., Kelly et al., 2020), athletes were assigned a BQ based on their selection year. These were subsequently compared to the expected distributions from the calculated average national live births in England and Wales from 1999 to 2008 to provide a similar age of birth to that of the sample (Office for National Statistics, 2015).

Data Analysis

Chi-square (χ^2) goodness of fit analysis was used to compare BQ distributions in the sample against population values (Office for National Statistics, 2015) following procedures outlined by McHugh (2013). As this test does not reveal the magnitude of difference between BQ distributions for significant chi-square outputs, Cramer's V was also used. The Cramer's V was interpreted as per conventional thresholds for correlation: a value of 0.06 or more would indicate a small effect size, 0.17 or more would indicate a medium effect size, and 0.29 or more would indicate a large effect size (Cohen, 1988). Odds ratios (ORs) and 95% confidence intervals (CIs) were used to compare BQs for observed and expected distributions. For all the tests, results were

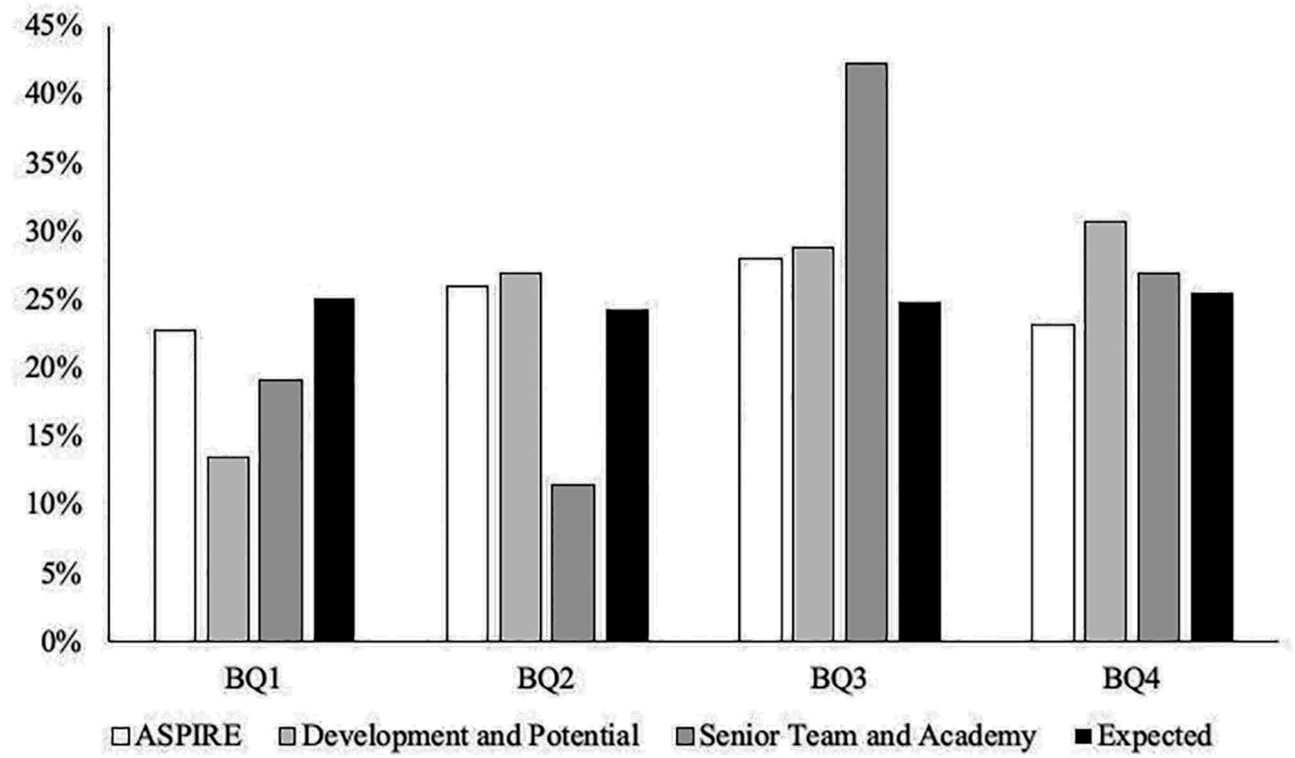

FIGURE 2 | The distribution of BQs in athlete's respective cohort and expected distribution from national norms (Office for National Statistics, 2015).

considered statistically significant when $P < 0.05$. All statistical analyses were conducted using IBM SPSS Statistics Version 24.

RESULTS

In line with the England Squash talent pathway selection levels, results are presented in ascending order: (a) ASPIRE, (b) Development and Potential, and (c) Senior team and Academy. Total combined male and female results are then also presented. First, there was no significant difference in the ASPIRE BQ distributions compared to national norms [$\chi^2_{(df=3)} = 2.292$, $P = 0.514$, $V = 0.07$; see **Figure 2**]. There were also no significant ORs found between BQ distributions. Second, there was no significant difference in the Development and Potential BQ distributions compared to national norms [$\chi^2_{(df=3)} = 3.872$, $P = 0.238$, $V = 0.19$; see **Figure 2**]. There were also no significant ORs found between BQ distributions. Third, there was no significant difference in the Senior team and Academy BQ distributions compared to national norms [$\chi^2_{(df=3)} = 5.290$, $P = 0.152$, $V = 0.32$; see **Figure 2**]. There were also no significant ORs found between BQ distributions. Finally, there was no significant difference in the male combined cohort BQ distributions compared to national norms [$\chi^2_{(df=3)} = 5.290$, $P = 0.152$, $V = 0.32$; see **Figure 3**]. There were also no significant ORs found between BQ distributions. Furthermore, there was no significant difference in the female combined cohort BQ distributions compared to national norms [$\chi^2_{(df=3)} = 5.290$, $P = 0.152$, $V = 0.32$; see **Figure 3**]. There were also no significant ORs found between BQ distributions. The descriptive statistics for all three cohorts as well as the total combined male and female cohorts are presented in **Table 1**.

DISCUSSION

The aim of the current study was to examine RAEs within the English Squash talent pathway. This sports setting provides a unique context to examine RAEs because they group players into *birthday-bands* rather than traditional (bi)annual-age groups. Findings reveal that there were no observed RAEs within the England Squash talent pathway across all cohorts. In recognizing that numerous factors may contribute to the lack of an observed RAE, the following sections explore potential explanations for these findings and discuss the limitations and future directions of this research.

Given the pervasive nature of RAEs in youth sports (Cobley et al., 2009; Smith et al., 2018), it is interesting to consider the lack of RAEs within the squash setting. There are several possible explanations for this insignificant RAE. First, previous studies have found inconsistent RAEs within senior racquet sport contexts (e.g., Ulbricht et al., 2015; Romann et al., 2018; Faber et al., 2019). In line with the current study's findings, previous research in racquet sports, such as badminton (e.g., Nakata

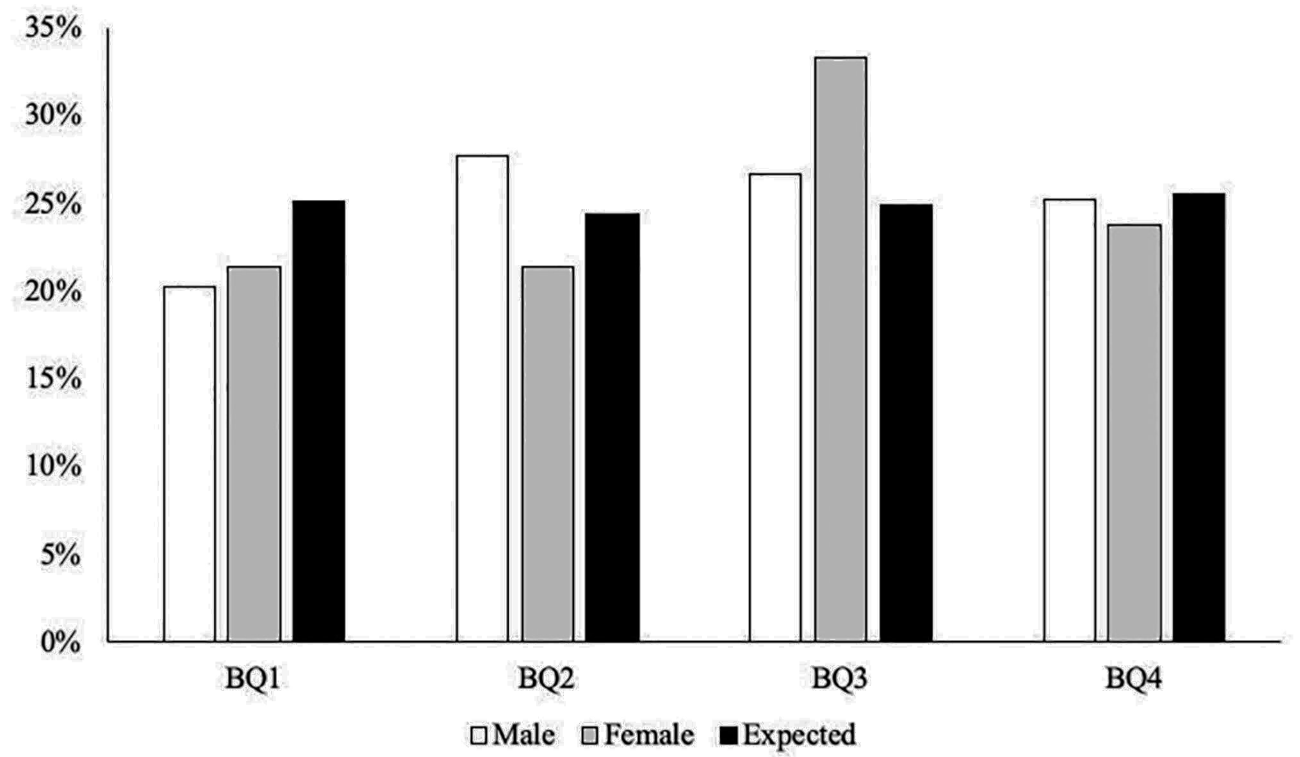

FIGURE 3 | The distribution of BQs in male and female combined cohorts and expected distribution of national norms (Office for National Statistics, 2015).

TABLE 1 | The distributions of BQs with chi-square, Cramer's V, and OR analysis.

Quartile distributions (ONS)	BQ1 (25.12%)	BQ2 (24.39%)	BQ3 (24.93%)	BQ4 (25.56%)	Total	χ^2 ($df = 3$)	*P*	Cramer's V	BQ1 vs. BQ4 OR (95% CI)
ASPIRE	57 (62.80)	65 (60.98)	70 (62.32)	58 (63.90)	250	2.292	0.514	0.07	1.00 (0.604; 1.657)
Development and potential	7 (13.06)	14 (12.68)	15 (12.96)	16 (13.29)	52	3.822	0.281	0.19	0.45 (0.138; 1.436)
Senior team and academy	5 (6.53)	3 (6.34)	11 (6.48)	7 (6.65)	26	5.290	0.152	0.32	0.73 (0.150; 3.514)
Male combined cohort	41 (50.74)	56 (49.27)	54 (50.36)	51 (51.63)	202	3.061	0.382	0.09	0.82 (0.465; 1.439)
Female combined cohort	27 (31.65)	27 (30.73)	42 (31.41)	30 (32.21)	126	4.857	0.183	0.14	0.91 (0.448; 1.872)

and Sakamoto, 2013), table tennis (e.g., Faber et al., 2019), and tennis (e.g., Ulbricht et al., 2015) finds no significant differences in BQ distributions at a senior level. Conversely, however, the present study finds no RAEs at youth levels, whereas RAEs are well-established in other youth racquet sports, including badminton (e.g., Romann et al., 2018), table tennis (e.g., Faber et al., 2020), and tennis (e.g., Loffing et al., 2010). Due to these conflicting findings, it is worthwhile to further explore the organizational and sociocultural structures that may be influencing the occurrence of RAEs at the youth level in other sporting contexts.

Second, it is possible to suggest that the use of birthday-banding for group players within the England Squash talent pathway may contribute to the insignificant RAEs. As discussed, birthday-banding offers athletes the opportunity to consistently shift between being the relatively oldest and the relatively youngest player based on their individual age throughout development. As a result, this strategy may be more accurate in capturing the dynamic nature of the athlete development process (Collins and MacNamara, 2012; Collins et al., 2016). More specifically, rather than competing in *fixed* (bi)annual-age groups (i.e., being relatively older or relatively younger throughout development), the birthday-banding strategy facilitates more diverse experiences (i.e., being both relatively older *and* relatively younger throughout development). Nevertheless, it is important to recognize that there may be other contributing factors that influence the equal BQ distributions throughout the selection levels (e.g., social context, competition level, and the number of active participants; Musch and Grondin, 2001). Thus, further research with a larger sample size in a different sports context is required before results are generalizable.

In order to understand the potential benefits of this strategy, literature examining mixed-age and play can be drawn upon. Evidence exists to suggest that older and younger participants can draw unique benefits from playing with each other. For example, relatively older athletes can experience opportunities for leadership and helping of younger peers (Côté et al., 2007; Jarvis, 2007). On the other hand, relatively younger athletes may benefit from the opportunity to hone their skills and compete against older teammates (Gibbs et al., 2012; Kelly et al., 2020). Because birthday-banding enables this shift between being relatively older and younger among one's peers, it may offer athletes more diverse developmental experiences along the talent pathway. Further, the potential for increased diversity extends beyond athletes' relative age within their peer group. For example, athletes may also have increased opportunities to interact with different coaches as well as engage in different types of activities. Collectively, these diverse experiences may facilitate athletes' immediate, short-, and long-term developmental outcomes (Côté et al., 2014).

Another potential benefit for the birthday-banding approach may be that it enables athletes to experience different types of social comparison environments. According to Wood and Wilson (2003), social comparison theory suggests that athletes rely on peers and teammates as a frame of reference to compare themselves, which is used to build self-perceptions, such as competence and identity. Applied to the birthday-banding context, it is possible that opportunities to be the relatively older athlete in the group provide a positive setting for athletes to compare themselves with others. In doing so, birthday-banding may enable a greater number of athletes to experience being the top performer within their group. On the other hand, when athletes move to the older age groups, they may be required to reevaluate their self-perceptions in relation to their new peer group (Goldman et al., under review). By amplifying opportunities for social comparison, the birthday-banding approach may encourage youth to develop a more dynamic and resilient sense of self throughout development. Given the limited body of literature on this topic, further research is warranted to substantiate this claim.

The origins of RAEs must also be considered when interpreting the insignificant BQ distributions throughout each cohort. For instance, gender (i.e., male vs. female), sport type (i.e., team vs. individual), and competition level (e.g., recreational participation vs. talent development) may play an important role in constructing RAEs (Cobley et al., 2009). First, previous research documents stronger RAEs in males when compared to females (e.g., Brustio et al., 2019). However, because the current findings reveal no differences between BQ distributions in both male and female cohorts, birthday-banding may be a useful grouping strategy to moderate RAEs within both genders. Second, the individual nature of squash may be a contributing factor toward the insignificant BQ distributions. Previous meta-analytic findings from Smith et al. (2018) reveal female team sports are associated with higher RAE estimates when compared to individual sports (ORs = team 1.33 vs. individual 1.18). This may be due to the comparisons between team sports athletes that occur during competition and are often subjective in nature, thus potentially placing greater emphasis on physiological differences (Baker et al., 2014). When considering the birthday-banding approach in a team sport context, however, it may prove difficult to implement due to squad requirements and additional administrative duties. Finally, previous studies document higher RAEs with increased competition level. Because the England Squash talent pathway is the highest competition level within the sport, it is plausible to suggest that it may be at greater risk of RAEs when compared to recreational participation. Thus, in light of the insignificant BQ distributions, the current findings suggest that birthday-banding may be a particularly robust grouping approach to moderate RAEs at the highest competition levels.

Alternative Organizational Structures

To understand the findings of the present study, it is also worthwhile to examine the literature on other strategies designed to moderate RAEs. For instance, Romann and Cobley (2015) and Cobley et al. (2019) have devised a method named *corrective adjustments* as a solution to remove RAEs in timed sports, such as athletics and swimming. Corrective adjustments refer to a process in which regression equations are applied through birthdate distribution and raw performance times with the disseminations of performance levels subsequently reexamined for greater relative age equality. Although this strategy may be appropriate for timed sports, it may be difficult to implement within racquet sports, such as squash, due to the interactive nature and scoring processes.

One strategy that may be particularly relevant for the present study is the *bio-banding* approach (Malina et al., 2019). Bio-banding involves grouping athletes based on their biological age as determined by their individual maturation status. This approach appears advantageous because it reduces inequality in competition that occurs due to growth and maturation differences between athletes in the same (bi)annual-age group (Malina et al., 2015). More specifically, when athletes with larger body types compete against each other, they have been shown to rely less on their size and more on their skill to succeed (Cumming et al., 2018). At the same time, when athletes with smaller body types compete against each other, they may be exposed to more manageable levels of challenge (Malina et al., 2015; Bradley et al., 2019). Interpreting these findings in light of the current study, it is possible that both bio-banding and birthday-banding may provide youth with competitive experiences that are tailored to individual developmental trajectories. However, Cumming et al. (2017) explicitly state this tool is designed to moderate maturation biases and should not be confused with mitigating RAEs as current research suggests only a weak-to-moderate proxy of maturation in youth athletes. In contrast though, Smith et al. (2018) meta-analysis reveals female weight-categorized sport types are generally not associated with RAEs, suggesting anthropometric bands may indeed be a useful strategy to moderate RAEs in youth sports. As such, further research exploring the influence of these strategies on RAEs in various youth sport contexts is warranted.

One of the potential advantages of the birthday-banding approach is that it may remove the effects of selection biases. Whereas, previous studies focus on interventions designed to target selection biases, birthday-banding may eliminate the need for such interventions. For example, researchers have proposed methods, such as establishing *selection quotas* (i.e., organizations are required to select a minimum number of athletes from each BQ; Kyle et al., 2019) or applying *age-ordered shirt numbering* systems (Mann and van Ginneken, 2017), which may be useful strategies for minimizing selection biases within (bi)annual-age groups. Within the birthday-banding context, such strategies may be less relevant as young players are not restricted to a fixed group or BQ throughout the year or during their development, respectively. Rather, by using an athlete's birthday as a proxy indicator of their readiness to progress to higher competition levels, this approach may more accurately capture the dynamic nature of athletes' developmental needs, which may change throughout the course of a competitive season.

Given the limited body of research on youth grouping in sports, it may also be worthwhile to examine grouping research within educational contexts, which has similarly explored issues relating to the effects of grouping strategies on academic achievement (Thompson et al., 2004). Two forms of grouping strategies that have received considerable attention in education include (a) *achievement grouping*, which refers to a constellation of processes whereby students of similar achievement levels are placed together for the purpose of tailoring educational experiences to student needs, and (b) *acceleration*, which involves students who progress through school faster in relation to their peers (i.e., *skipping a grade*; Neihart, 2007; Steenbergen-Hu et al., 2016). Because the aim of these strategies is to provide youth with developmentally appropriate learning opportunities, they share similarities with the birthday-banding approach. It may, thus, be useful for sport researchers to draw upon this literature to integrate a wider range of concepts and theories to inform their grouping strategies. In doing so, researchers can expand beyond the silo of sport science to improve the quality and equity of talent pathways.

Limitations and Future Directions

The authors acknowledge that it is difficult to fully determine birthday-banding as the solitary cause of the equal BQ distributions throughout the England Squash talent pathway. Because athlete development is a complex and multidimensional process (e.g., Kelly and Williams, 2020), it is important to appreciate that there may be other contributing factors that have influenced the balanced BQ distributions throughout the selection levels (e.g., social context, competition level, and the number of active participants; Musch and Grondin, 2001). As an example, it has been previously documented that, during a comparison of different youth sports, those with greater popularity often comprise a stronger RAE (Lupo et al., 2019). As such, it may be argued that the lower participation levels of squash compared to other sports in England (e.g., soccer) may result in less difficulty during the selection process, and thus, a weaker RAE occurs. Furthermore, although the small sample limits the statistical power of the cohorts, it provides an accurate and comprehensive representation of the England Squash talent pathway, which offers a contextualized assessment of RAEs within a real-world setting. It is encouraged that future research replicate this study design within a larger cohort to ensure the birthday-banding strategy is generalizable. In addition, although male and female combined cohorts were analyzed to explore the overall gender differences, due to the small sample size and to ensure an appropriate level of statistical rigor was applied, gender comparisons within each selection level were not included as part of the analysis. However, because mixed-gender training and competition regularly operate throughout the England Squash talent pathway, it represents an accurate representation of each cohort. Nevertheless, exploring additional gender differences represents a fruitful avenue for future research.

The current findings offer an insight into the potential outcomes of birthday-banding. However, numerous questions remain to understand how this approach is viewed and experienced by key stakeholders. As such, investigations with athletes, coaches, and peers may extend beyond our current understanding of the lived experience of participating in sport settings that adopt this grouping approach. Qualitative and observational methodologies may be instrumental in addressing this gap. Indeed, studies employing these methods may shed light on the potential mechanisms underpinning the association between birthday-banding and RAEs. Furthermore, it is important to acknowledge that this study only assessed birthday-banding at one point in time. As such, future studies can build upon this research by using longitudinal designs to investigate the effects of the birthday-banding approach throughout athletes' developmental trajectories.

CONCLUSION

In sum, the findings from this current study are consistent with other RAE research among racquet sports (e.g., badminton, table tennis, tennis) at adulthood (i.e., Senior team and Academy selection levels), whereby no significant difference in BQ distributions were revealed. However, while exploring the youth selection levels (i.e., ASPIRE, Development, and Potential), the results from this current study are contrary to existing RAE literature in other racquet sports, whereby no significant differences in BQ distributions were apparent. The authors introduce the concept of birthday-banding, which has been widely adopted by the England Squash talent pathway as a grouping strategy with the main purpose of moderating the RAE. Although it is difficult to interpret birthday-banding as the single cause for there being no RAEs throughout the England Squash talent pathway, it can be suggested that it is more representative of the dynamic nature of the athlete development process when compared to fixed (bi)annual-age grouping. Coaches and practitioners working in youth sports are encouraged to challenge traditional age group structures to help eliminate annual-age biases throughout athlete development systems.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Birmingham City University Health, Education and Life Sciences Faculty Academic Ethics Committee. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

DJ, JJT, and MJ primarily focused on the Methods and Results sections, whereas AK and JT contributed more to the Introduction, Discussion, and Conclusion. All authors were involved with compiling the data, as well as writing the full manuscript.

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REFERENCES

Baker, J., Janning, C., Wong, H., Cobley, S., and Schorer, J. (2014). Variations in relative age effects in individual sports: Skiing, figure skating and gymnastics. *Eur. J. Sport Sci.* 14, 183–190. doi: 10.1080/17461391.2012.671369

Baker, J., Schorer, J., and Cobley, S. (2010). Relative age effects. *Sportwissenschaft* 40, 26–30. doi: 10.1007/s12662-009-0095-2

Baker, J., Horton, S., Robertson-Wilson, J., and Wall, M. (2003). Nurturing sport expertise: Factors influencing the development of elite athlete. *J. Sports Sci. Med.* 2, 1–9.

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *CAHPER J.* 51, 23–28.

Baxter-Jones, A. (1995). Growth and development of young athletes: should competition be age related? *Sports Med.* 20, 59–64. doi: 10.2165/00007256-199520020-00001

Bradley, B., Johnson, D., Hill, M., McGee, D., Kana-ah, A., Sharpin, C., et al. (2019). Bio-banding in academy football: player's perceptions of a maturity matched tournament. *Ann. Hum. Biol.* 46, 400–408. doi: 10.1080/03014460.2019.1640284

Brustio, P. R., Kearney, P. E., Lupo, C., Ungureanu, A. N., Mulasso, A., Rainoldi, A., et al. (2019). Relative age influences performance of world-class track and field athletes even in the adulthood. *Front. Psychol.* 10:1395. doi: 10.3389/fpsyg.2019.01395

Côté, J., Baker, J., and Abernethy, B. (2007). "Practice and play in the development of sport expertise," in *Handbook of Sport Psychology, 3rd Edn,* eds G. Tenenbaum and R. C. Eklund (Hoboken, NJ: Wiley), 184–202. doi: 10.1002/9781118270011.ch8

Côté, J., Turnnidge, J., and Evans, M. B. (2014). The dynamic process of development through sport. *Kinesiologica Slovenica* 20, 14–26.

Cobley, S., Abbott, S., Dogramaci, S., Kable, A., Salter, J., Hintermann, M., et al. (2018). Transient relative age effects across annual age groups in national level Australian swimming. *J. Sci. Med. Sport* 21, 839–845. doi: 10.1016/j.jsams.2017.12.008

Cobley, S., Abbott, S., Eisenhuth, J., Salter, J., McGregor, D., and Romann, M. (2019). Removing relative age effects from youth swimming: the development and testing of corrective adjustments procedure. *J. Sci. Med. Sport.* 22, 735–740. doi: 10.1016/j.jsams.2018.12.013

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S. P., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: L. Erlbaum Associates.

Collins, D., and MacNamara, Á. (2012). The rocky road to the top: why talent needs trauma. *Sports Med.* 42, 907–914. doi: 10.1007/BF03262302

Collins, D. J., MacNamara, Á., and McCarthy, N. (2016). Putting the bumps in the rocky road: optimizing the pathway to excellence. *Front. Psychol.* 7:1482. doi: 10.3389/fpsyg.2016.01482

Cumming, S. P., Brown, D. J., Mitchell, S., Bunce, J., Hunt, D., Hedges, C., et al. (2018). Premier League academy soccer players' experiences of competing in a tournament bio-banded for biological maturation. *J. Sports Sci.* 36, 757–765. doi: 10.1080/02640414.2017.1340656

Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C., and Malina, R. M. (2017). Bio-banding in sport: Applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength Cond. J.* 39, 34–47. doi: 10.1519/SSC.0000000000000281

Dudink, A. (1994). Birth date and sporting success. *Nature* 368, 592–592. doi: 10.1038/368592a0

Edgar, S., and O'Donoghue, P. (2005). Season of birth distribution of elite tennis players. *J. Sports Sci.* 23, 1013–1020. doi: 10.1080/02640410400021468

England Squash (2020). *Talent Pathway.*. Retrieved from: https://www.englandsquash.com/performance/talent-pathway (accessed September 2, 2020).

Faber, I. R., Liu, M., Cece, V., Jie, R., Martinent, G., Schorer, J., et al. (2019). The interaction between within-year and between-year effects across ages in elite table tennis in international and national contexts – A further exploration of relative age effects in sports. *High Ability Stud. 31,* 115–128. doi: 10.1080/13598139.2019.1596071

Faber, I. R., Martinent, G., Cece, V., and Schorer, J. (2020). Are performance trajectories associated with relative age in French top 100 youth table tennis players? *– A longitudinal approach. PLoS ONE* 15: e0231926. doi: 10.1371/journal.pone.0231926

Filipcic, A. (2001). Birth date and success in tennis. *ITF Coach. Sport Sci. Rev.* 23, 9–11.

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? *The relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. Int. Rev. Sociol. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Gil, S. M., Bidaurrazaga-Letona, I., Martin-Garetxana, I., Lekue, J. A., and Larruskain, J. (2020). Does birth date influence career attainment in professional soccer? *Sci. Med. Football* 4, 119–126. doi: 10.1080/24733938.2019.1696471

Helsen, W. F., van Winckel, J., and Williams, A. M. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Jarvis, P. (2007). Dangerous activities within and invisible playground: a study of emergent male football play and teachers' perspectives of outdoor free play in the early years of primary school. *Int. J. Early Years Educ.* 15, 245–259. doi: 10.1080/09669760701516918

Kelly, A. L., Wilson, M. R., Gough, L. A., Knapman, H., Morgan, P., Cole, M., et al. (2020). A longitudinal investigation into the relative age effect in an English professional football club: Exploring the 'underdog hypothesis'. *Sci. Med. Football* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Kelly, A. L., Wilson, M. R., and Williams, C. A. (2018). Developing a football-specific talent identification and development profiling concept – the locking wheel nut model. *Appl. Coach. Res. J.* 2, 32–41.

Kelly, A. L., and Williams, C. A. (2020). Physical characteristics and the talent identification and development processes in male youth soccer: a narrative review. *Strength Cond J.* doi: 10.1519/SSC.0000000000000576. [Epub ahead of print].

Kyle, J. M., Bennett, R. V., and Fransen, J. (2019). Creating a framework for talent identification and development in emerging football nations. *Sci. Med. Football* 3, 36–42. doi: 10.1080/24733938.2018.1489141

Loffing, F., Schorer, J., and Cobley, S. P. (2010). Relative age effects are a developmental problem in tennis: but not necessarily when you're left-handed! *High Ability Stud.* 21, 19–25. doi: 10.1080/13598139.2010.488084

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2019.01465

Malina, R. M., Cumming, S. P., Rogol, A. D., Coelho-e-Silva, M. J., Figueiredo, A. J., Konarski, J. M., et al. (2019). Bio-banding in youth sports: background, concept, and application. *Sports Med.* 49, 1671–1685. doi: 10.1007/s40279-019-01166-x

Malina, R. M., Rogol, A. D., Cumming, S. P., Coelho-e-Silva, M. J., and Figueiredo, A. J. (2015). Biological maturation of youth athletes: assessment and implications. *Br. J. Sports Med.* 49, 852–859. doi: 10.1136/bjsports-2015-094623

Mann, D. L., and van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci.* 35, 784–790. doi: 10.1080/02640414.2016.1189588

McHugh, M. L. (2013). The chi-square test of independence. *Biochemia Medica* 23, 143–149. doi: 10.11613/BM.2013.018

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Nakata, H., and Sakamoto, K. (2013). Relative age effects in Japanese baseball: a historical analysis. *Percept. Mot. Skills* 117, 276–289. doi: 10.2466/10.25.PMS.117x13z1

Neihart, M. (2007). The socioaffective impact of acceleration and ability grouping: recommendations for best practice. *Gifted Child Quart.* 51, 330–341. doi: 10.1177/0016986207306319

Office for National Statistics (2015). *Number of Live Births by Date, 1995 to 2014, in England and Wales. Retrieved from:* https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/005149numberoflivebirthsbydate1995to2014inenglandandwales (accessed May 12. 2018].

Romann, M., and Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS ONE* 10:e0122988. doi: 10.1371/journal.pone.0122988

Romann, M., Rössler, R., Javet, M., and Faude, O. (2018). Relative age effects in Swiss talent development – a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–2031. doi: 10.1080/02640414.2018.1432964

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Steenbergen-Hu, S., Makel, M. C., and Olszewski-Kubilius, P. (2016). What one hundred years of research says about the effects of ability grouping and acceleration on K—12 students' academic achievement: findings of two second-order meta-analyses. *Rev. Educ. Res.* 86, 849–899. doi: 10.3102/0034654316675417

Stratton, G., Reilly, T., Williams, A. M., and Richardson, D. (2004). *Youth Soccer: From Science to Performance.* London: Routledge.

Thompson, A. H., Barnsley, R. H., and Battle, J. (2004). The relative age effect and the development of self-esteem. *Educ. Res.* 46, 313–320. doi: 10.1080/0013188042000277368

Turnnidge, J., Hancock, D. J., and Cote, J. (2014). The influence of birth date and place of development on youth sport participation. *Scand J. Med. Sci. Sports* 24, 461–468. doi: 10.1111/sms.12002

Ulbricht, A., Fernandez-Fernandez, J., Mendez-Villanueva, A., and Ferrauti, A. (2015). The relative age effect and physical fitness characteristics in German male tennis players. *J. Sports Sci. Med.* 14, 634–642.

US Squash (2019). *Squash Facts*. Retrieved from: https://www.ussquash.com/squash-facts/ (accessed *October 22*, 2019).

Webdale, K., Baker, J., Schorer, J., and Wattie, N. (2019). Solving sport's "relative age" problem: a systematic review of proposed solutions. *Int. Rev. Sport Exerc. Psychol.* 13, 187–204. doi: 10.1080/1750984X.2019.1675083

Wood, J. V., and Wilson, A. E. (2003). "How important are social comparisons for self-evaluation?," in *Handbook of Self and Identity,* eds M. R. Leary, and J. P. Tangney (New York, NY: Guilford Press), 344–366.

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Origins of Relative Age Effects in Youth Football—A Nationwide Analysis

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Introduction: Relative age effects (RAEs) refer to the overrepresentation of players born earlier in the selection year compared to late-born players within the same age category. To date, the origins and mechanisms of RAEs are still unclear. To evaluate the development of RAEs in terms of age group and selection level, we analyzed data of all registered child and adolescent football players in Switzerland.

Methods: Age category, selection level, and birthdate from all licensed 101,991 Swiss child and youth football players assigned to a specific team [9,149 girls (9.0%) and 92,842 boys (91.0%); age range: 4.6–19.6 years] were analyzed. Additionally, out of 1,128 clubs, 54 clubs provided their documented waiting lists (1,224 players). Birthdate distributions were split by age category, sex, and birth quarter (Q1 = January to March, Q4 = October to December). RAEs were calculated using odds ratios (Q1 vs. Q4) with 95% confidence intervals (95% CI).

Results: We found small RAEs among U8 players (OR 1.44 [95% CI 1.31, 1.59]) and U10 (OR 1.24 [95% CI 1.16, 1.32]). The RAE was negligible in all other age categories, independent of gender. In children's football, 5,584 (71.3%) teams performed selections. In teams without selection, there were no obvious RAEs. However, teams with selections for the same age category showed small RAEs with an overrepresentation of Q1 athletes in the first team (OR = 1.29 [95% CI 1.24, 1.35]) and inverse RAEs with an underrepresentation of Q1 athletes in the last team (OR = 0.85 [95% CI 0.82, 0.89]). Only small RAEs were observed on the waiting lists for the U8 (OR = 1.48 [1.13, 1.95]).

Discussion and Conclusion: RAEs have a small, but consistent effect on participation in Swiss children's football at the grassroots level. Contrary to expectations, no inverse RAEs were found on the waiting lists. Nonetheless, first time coach selections seem to be the origin of RAEs. To protect young athletes from discrimination, RAE biases should be analyzed and eliminated at all stages of sport participation, selection, and dropout situations. Modifications to the organizational structure of sport and athlete development systems are recommended to prevent RAE-related discrimination in youth sports.

Keywords: youth sports, talent selection, talent development, waiting lists, youth football, relative age effect

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INTRODUCTION

The practice of annual age grouping occurs throughout and across youth sport. In football (soccer), players are typically categorized into annual age groups to reduce developmental differences during childhood and adolescence. However, there is a potential gap of up to 12 months in chronological age between individuals in the same age category. Relative age effects (RAEs) are defined as the overrepresentation of chronologically older participants within one selection category (Cobley et al., 2009).

RAEs have been demonstrated in a wide variety of sports. Cobley et al. (2009), for instance, report RAEs in 14 different sports (ice hockey, volleyball, basketball, American football, Australian rules football, baseball, soccer, cricket, swimming, tennis, gymnastics, netball, Rugby Union, and golf) in male and female youth athletes from 4 years of age to adulthood. RAEs are present in all age categories and increase with age. The largest effects are observed in basketball and football. In a population-based study, RAEs in all youth athletes who were registered in the Swiss talent development program in the year 2014 were analyzed (Romann et al., 2018). A large variability in RAEs was found across different types of sports and between girls and boys. Overall, RAE was present for athletes of both sexes, with considerably larger RAE in male athletes competing at national level or in Olympic sports than male athletes competing at a lower selection level or in non-Olympic sports, respectively. Similarly, population-based analyses in France showed RAEs in basketball and football (Delorme et al., 2010, 2011). In Switzerland, population-based analyses of athletes aged 10–20 years showed RAEs in men's Swiss football and athletics (sprinting) (Romann and Fuchslocher, 2013; Romann and Cobley, 2015), as well as in women's alpine skiing, tennis, football, athletics, fencing, snowboarding, and inverse RAEs in table tennis (Romann and Fuchslocher, 2011, 2014).

RAEs can occur during the early development of youth athletes (Cobley et al., 2009; Smith et al., 2018) and may lead to a biased view of the potential of children in a particular sport. As athletes born earlier in the competition year may have more advanced physical and cognitive abilities compared to their late-born opponents, they are likely to be identified as more talented (Cobley et al., 2009; Gil et al., 2014; Wattie et al., 2015; Smith et al., 2018). Furthermore, RAEs can lead to an increased dropout from sports, with an underrepresentation of dropouts among athletes born early in the competition year and an overrepresentation among those born late in the year shown in a sample of almost 75,000 young (9–15 years) basketball players (Delorme et al., 2011). A very similar observation, i.e., an over-representation of dropouts born late in the competitive year, was reported in an analysis of more than 360,000 male French football players in the U9 to the U18 age categories (Delorme et al., 2010).

It is generally assumed that physiological growth and maturation are major underlying causes of RAEs (Cobley et al., 2009). However, there is evidence that RAEs are present before puberty and, therefore, prior to maturity-associated selection biases. Furthermore, RAEs are also found, in academia, where physical capabilities are negligible (Musch and Grondin, 2001). However, playing experience, cognitive, emotional, behavioral, motor, and social development are more likely to follow age than maturity. Therefore, such differences in development are more likely to be the underlying causes of RAEs than (differences in) maturity in athleticism (i.e., speed, power, and strength). Furthermore, several aspects, such as the popularity of a particular sport, the number of active participants, the importance of physical development and the competitive level may affect the magnitudes of RAEs (Musch and Grondin, 2001). RAEs are likely larger with high rates of participation and high selection pressure.

Additionally social agents like parents, coaches, and athletes (Cobley et al., 2009) influence RAEs. They falsely associate physical maturity with actual skill differences, and through accelerated RAEs, which have been explained with the Matthew effect, the Pygmalion effect, and the Galatea effect (Hancock et al., 2013).

However, to date, little is known about the origins of RAEs. In football, it may be speculated that RAEs increase with age and are larger in teams of higher playing levels, based on increasing selection pressure. Thus, RAEs can be expected to be smaller or even inexistent in low-level youth teams in young age groups. Accordingly, the aim of this study was to address the effect of playing levels, age groups, and selection approaches (self-selection, waiting lists, and selection by team coaches) on the occurrence of RAEs, by analyzing a population-based sample of youth football players in Switzerland.

The objectives of this study therefore were (i) to investigate RAEs in a nationwide analysis of football players (5–20 years of age), who are registered as active players assigned to an individual team in the database of the Swiss Football Association (SFA) and (ii) to evaluate the effects of different selection procedures on RAEs.

MATERIALS AND METHODS

Participants

Following ethical approval from the Swiss Federal Institute of Sport (App. No: 082_LSP_150819), RAEs of 101,991 junior football players [9,149 girls (9.0%) and 92,842 boys (91.0%), age range: 4.6–19.6 years] participating in one of 1,128 football clubs were analyzed. Age categories ranged from under- (U) 8 to U20 for male and from U12 to U19 for female football (FF) players. Including cases where players played in two teams (different levels or different categories), we analyzed 109,469 single data points in Swiss Football Juniors' leagues during the year 2019 (**Table 1**).

Data were taken from the national football database with permission of SFA. In addition, all Swiss football clubs with children football's sections (U8–U12, $N = 1,128$ clubs) were contacted via email and asked whether they have (a) no waiting list; (b) anonymous waiting list, but not documented; or (c) anonymous documented waiting list. Under the term waiting list, we understand that some children sometimes cannot enter a club due to a lack of infrastructure or coaches, for example, and have to wait for a place in a football team. Out of the 1,128 clubs, 556 (49%) responded and 54 delivered their documented waiting lists, which included 1,271 players. Due to the low number of girls

TABLE 1 | Subject characteristics and age categories in Swiss youth male and female soccer.

Age group	*N*	Age
Mixed sex football		
U8	3,956 (286 ♀)	6.4 ± 1.1
U10	8,316 (460 ♀)	8.1 ± 1.2
U12	23,234 (1,349 ♀)	9.7 ± 0.8
U14	23,276 (1,142 ♀)	11.5 ± 0.7
U16	17,870 (948 ♀)	13.5 ± 0.7
U18	13,250 (91 ♀)	15.5 ± 0.7
U20	9,817 (39 ♀)	17.7 ± 1.0
Subtotal U8 to U20	99,719 (4,315 ♀)	
Female football (FF)		
FF-12	561	10.3 ± 1.1
FF-15	2,880	12.8 ± 1.3
FF-19	1,994	15.5 ± 1.2
Subtotal FF12 to FF19	5,435	
Total ♂ + ♀	109,469	

♀, female; ♂, male.

TABLE 2 | Odds ratio (OR) in each age category for distribution in birth quarters (Q1/Q4) and semesters (S1/S2), boys' and girls' categories.

Age category	OR Q1/Q4	OR S1/S2
U8 ($N = 3,956$)	1.44 (1.31, 1.59)	1.24 (1.15, 1.32)
U10 ($N = 8,316$)	1.24 (1.16, 1.32)	0.81 (0.78, 0.84)
U12 ($N = 23,234$)	1.13 (1.08, 1.18)	1.04 (1.00, 1.08)
U14 ($N = 23,276$)	0.98 (0.93, 1.02)	0.95 (0.91, 0.99)
U16 ($N = 17,870$)	0.99 (0.94, 1.04)	0.96 (0.92, 1.00)
U18 ($N = 13,250$)	1.00 (0.95, 1.06)	0.94 (0.90, 0.98)
U20 ($N = 9,817$)	1.06 (1.00, 1.13)	1.01 (0.96, 1.06)
Total U8 to U20 ($N = 99,719$)	1.06 (1.03, 1.10)	1.00 (0.97, 1.03)
Female football (FF)		
FF-12 ($N = 561$)	1.10 (1.00, 1.41)	1.06 (0.94, 1.20)
FF-15 ($N = 2,880$)	0.94 (0.85, 1.05)	0.88 (0.81, 0.95)
FF-19 ($N = 1,994$)	0.84 (0.72, 0.98)	0.91 (0.81, 1.02)
Total FF-12 to FF-19 ($N = 5,435$)	0.96 (0.89, 1.04)	0.92 (0.87, 0.98)

on waiting lists in general and of boys in the age groups older than the U12 age category, only the waiting lists of boys in the categories from U8 to U12 were analyzed ($N = 1,224$ boys).

Procedures and Data Analysis

In Switzerland, the cutoff date for all sports is January 1st. The players were categorized into two semesters (S) and four relative age quarters (Q) according to their birth month independently of birth year (i.e., S1 = January to June; S2 = July to December and Q1 = January to March; Q2 = April to June; Q3 = July to September; and Q4 = October to December). The observed birthdate distributions were calculated for every relative age quarter. The expected birthdate distributions were obtained from the actual corresponding distributions (1999–2013) as the number of live births registered with the Swiss Federal Office of Statistics (2020). The relative age quarters of the Swiss population were as follows: Q1 = 24.5%; Q2 = 25.2%; Q3 = 26.1%; and Q4 = 24.2%. Self-selection in children's football was calculated using the distribution of the corresponding Swiss population and the distribution of registered players.

Birthdate distributions were split according to gender, age category, selection level, and birth quarter. There were up to seven selection levels possible in the same age category, from the best league to the last team of each age category within the same club. Age categories were analyzed as given by the SFA as follows: U8, U10, U12, U14, U16, U18, and U20 for the boys' categories in which girls are allowed to play, and FF-12, FF-15, and FF-19 for the only-girls' categories.

RAEs were calculated using odds ratios (Q1 vs. Q4 and S1 vs. S2) with 95% confidence intervals (95% CI). The OR for the Q1 vs. Q4 comparison was interpreted as follows: we assumed the existence of an RAE if the CI did not include 1 and interpreted an $OR < 1.22$, $1.22 \leq OR < 1.86$, $1.86 \leq OR < 3.00$, and $OR \geq 3.00$, as negligible, small, medium, and large, respectively (Olivier and Bell, 2013). If the OR was <1 and the CI did not include 1, this finding was interpreted as an inverse RAE. As population-based data were analyzed, inferential statistics were not applied (Gibbs et al., 2012).

RESULTS

The full dataset (both sexes across all age categories) shows a negligible RAE. When analyzing specific age categories, there are small RAEs in children's football (U8 and U10) and negligible RAEs in all other age categories, including FF-12 and FF-15. The FF-19 category shows an inverse RAE (**Table 2**).

Across all 1,128 clubs in childrens' football, 925 (82.0%) select multiple teams and 203 (18.0%) only select one team. Across all clubs 5,584 (71.3%) teams were built by selections and 2,250 (28.7%) were created without selection. Overall, there is a small RAE in the highest-level/first/top teams (OR = 1.29 [95% CI 1.24, 1.35]) and an inverse RAE for the lowest-level teams (OR = 0.85 [95% CI 0.82, 0.89]). Regarding specific age categories, there is a small RAE that decreases with age in the first/highest-level/top U8 to U14 teams. There is no RAE in older age categories for the first/highest-level/top teams, although OR is larger in the top/first/highest-level teams over all age categories (**Figure 1**). An inverse RAE with an overrepresentation of players born at the end of the selection year is found in the lowest-level teams in the U14, U16, and U18 age categories. Super, Challenge, and Promotion League Clubs show small overall RAE in their children's football teams (OR = 1.26 [95% CI 1.16, 1.36]), which decrease with age (**Figure 1**). None of the corresponding girl's categories show a relevant RAE.

Out of 556 children's football clubs that responded, 424 (76.3%) have no waiting list, 54 (9.7%) have a documented waiting list, 54 (9.7%) have a waiting list, but not documented, 16 (2.9%) have a periodic waiting list and 8 (1.4%) can offer an alternative program. All 54 clubs that delivered their waiting lists were included in the analysis. In total, the documented waiting

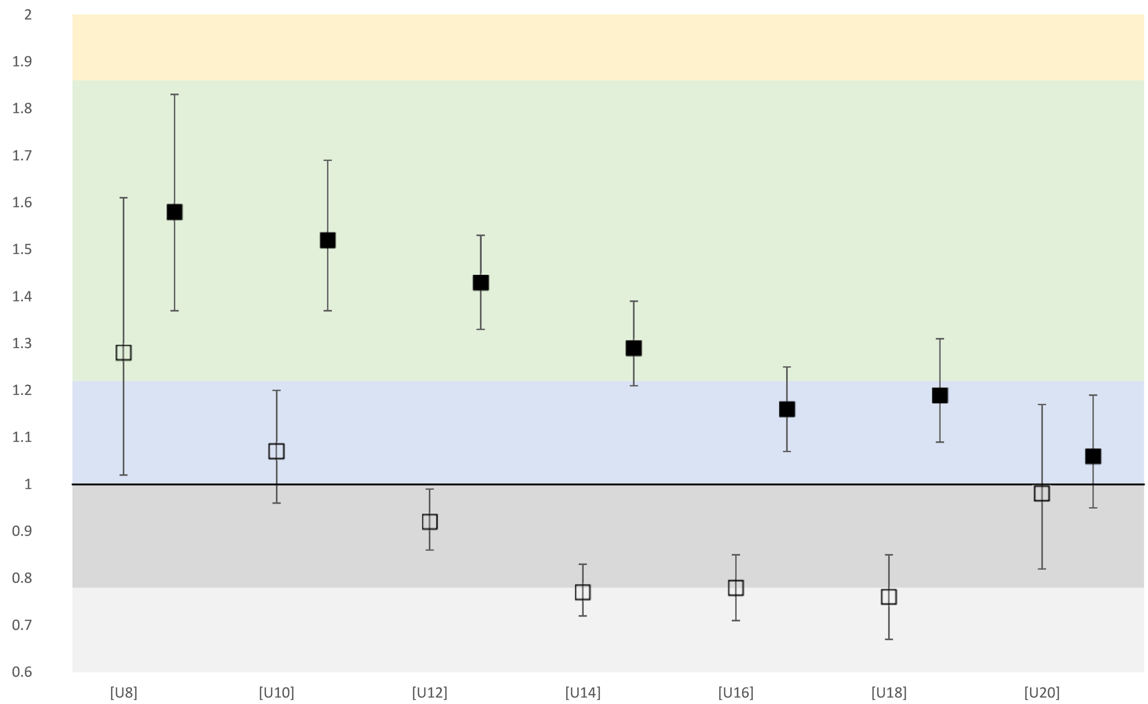

FIGURE 1 | First and last level teams OR with confidence interval for each age category (male). Empty squares represent the last level teams. Full squares represent the first-level teams. Light gray color, small inverse effect; gray color, negligible inverse effect; blue color, negligible positive effect; green color, small effect; yellow color, medium effect.

TABLE 3 | Odds ratios on the waiting lists of categories U8 to U12 by birth quarter (Q) and semesters (S1/S2), boys' and girls' categories.

Category	OR Q1/Q4	OR S1/S2
U8 (*N* = 453)	1.48 (1.13, 1.95)	1.09 (0.91, 1.32)
U10 (*N* = 505)	0.84 (0.66, 1.07)	0.89 (0.75, 1.07)
U12 (*N* = 266)	0.84 (0.60, 1.20)	1.06 (0.84, 1.36)
Total (*N* = 1,224)	1.03 (0.87, 1.21)	1.00 (0.89, 1.12)

lists contain $N = 1{,}271$ players (1,224 boys and 47 girls). The analysis of the boys' waiting lists shows a small RAE in the category U8 only (**Table 3**).

DISCUSSION

The main findings of this study are: (i) no relevant overall RAE, (ii) a small RAE in the youngest age group, i.e., at entry into the official football system, which decreases with age, (iii) a small effect of the current playing level of the team within the club, but not necessarily of the first adult team's playing level, and (iv) a small RAE on the waiting list of the youngest age category (U8).

Self-Selection

The results of our study show that RAEs already exist in the youngest category for both sexes. In other words, children born at the beginning of the selection year are more likely to participate in children's football. Older children are generally biologically more mature, taller, and heavier, with more body mass for body height than younger children. This leads to advantages in athletic performance and psychological aspects, which are referred to as the maturation-selection hypothesis (Cobley et al., 2009). Therefore, it could be speculated that children born at the end of the selection year may self-select prior to playing organized football. Nationwide analyses of male French football players show similar RAEs at entry level of youth football (Delorme et al., 2010) emphasizing/reinforcing our observation. Furthermore, Smith et al. (2018), who found small RAEs (OR = 1.25 [95% CI 1.21, 1.30]) in female athletes across all sports, including football, revealed that RAE magnitude is highest in pre-adolescent (U11) and at higher competition levels. These findings indicate a self-selection effect (first hurdle) for children of both sexes prior to participating in organized sport. Furthermore, the advantage of being born at the beginning of the selection year is more pronounced the younger the children. For example, in the youngest category of children's football (U8), the age difference between two children in the selection year can be up to 12.5%, whereas this difference is reduced to about 6% in the U16 age group (Cobley et al., 2020). Fundamentally, sport participation requires opportunities to engage in sport, and the motivation to engage in such opportunities. Children born earlier in the selection year are more likely to initiate early age group participation. This may be based on a combination of early sporting experiences and encouraging interactions with others (e.g., parents and peers; Balish et al., 2014). At a young age, role models, stereotypes of the sport (women's sport vs. men's sport), popularity, positive experiences, and existing opportunities are important for sport participation, although there is a need for more in-depth examination and refinement of important correlates at various levels (intra- and interpersonal, biological, institutional, community, and policy levels; Balish et al., 2014). Therefore, peers and or parents, who are present during a child's first sports experiences, may influence the decision to join a club. Furthermore, pre-selection by parents may occur if they do not support the child's sport club participation. Therefore, a child will only join a sports club, if these two obstacles (self-selection and pre-selection by parents) are overcome.

Coach Selection

Following club entry, further selection is conducted by coaches in over 80% of clubs, starting in the youngest age category. Coach selection seems to have a large influence on the magnitude of RAEs, with negligible RAEs due to self-selection greatly increasing as a result of first-time coach selection. This is highlighted by the fact that RAEs are higher in first teams compared to the following teams. Younger athletes may fail to meet selection requirements, as they are often biologically less developed. Therefore, their performance is likely to be poorer in age-based competition compared to athletes born earlier in the selection year. The RAEs disappear in girls in the U15 and in boys in the U14. These results differ from the results of Delorme, who found RAEs in all age categories of French basketball and football (Delorme and Raspaud, 2009). However, Delorme et al. (2010) used inferential statistics, which are not appropriate for population studies. If the data are transferred to ORs, no relevant RAEs (all ORs <1.22) were observed in U10 to adult categories for both female and male athletes. This means that RAEs at the grassroots level should be counteracted particularly in the first age categories (i.e., U8, U10).

Underlying Mechanisms

The underlying mechanisms of RAEs in young elite athletes are well-known. In performance-oriented sport, RAEs increase with higher participation numbers, higher selection pressure, and during the growth spurt in puberty (Cobley et al., 2009). Therefore, when only assessing performance-oriented sport, peak RAEs are often associated with the ages during puberty, between the ages of 11 and 15 years. However, RAEs may be highest in children's sport and decrease consistently until the beginning of the growth spurt, which leads to a second increase in RAEs (Cobley et al., 2020). Furthermore, coaches often focus on short-term success by selecting first teams in children's football that can win matches for the club (Jimenez and Pain, 2008). However, differences in global performance, as well as success during selections of youth players mainly depend on biological and physiological variables (Coelho et al., 2010), which are inaccurate in predicting later success in adolescence and adulthood. Continued selection into better/higher teams, extra training, and elite coaching could provide first-team athletes with a performance advantage (Wattie et al., 2015). Therefore, coaches contribute significantly to the increase of RAEs in youth sports. Additionally, success in youth sport can lead to increased effort and motivation due to positive feedback from coaches, parents, and peers, and, therefore, increase performance of an athlete (Cobley and Till, 2017). Conversely, de-motivation, due to a lack of participation and selection, or the perception of a selection bias, could lead to increased levels of dropout among children and adolescents (Delorme et al., 2011; Cobley et al., 2020). Furthermore, dropouts due to demotivation are enhanced in less psychosocially supportive environments, such as larger cities (Fraser-Thomas et al., 2008). Additionally, during the talent development pathway, following previous selection, coaches (for athletes aged 10–14 years) must perform selections using a pool of players, which is already unequally distributed due to RAEs from previous selections. This process increases RAEs and dropouts even more and has been linked to the Matthew effect, the Pygmalion effect, and the Galatea effect (Hancock et al., 2013). However, there are several measures that could reduce RAEs during entry in sport, selections, and dropouts.

Strategies to Counteract RAE Inequalities in Football

It is important to protect young athletes from age-related discrimination. To ensure this, every child should have the right to participate in sport without any age discrimination (Bergeron et al., 2015; Unicef, 2018). Therefore, RAE biases should be analyzed and eliminated at all stages of sport participation, more specifically (i) at the entry into grassroots sport participation (e.g., self-selection and club entry), (ii) in all selection procedures (e.g., waiting lists, selection into higher-performing teams), and (iii) in all dropout situations (e.g., transitions, de-selections).

Previous recommendations addressing RAE-specific inequalities are well-documented and include the creation of shorter (e.g., 6-month) and/or rotating age-group cutoff dates (Hurley et al., 2001), birthday-banding, whereby young athletes move up to their next age group on their birthday (Kelly et al., 2020), and grouping based on biological classifications (e.g., height and weight; Cumming et al., 2017). Furthermore, selection procedures at the grassroots level should be avoided. If they are indispensable, they should be improved so that no RAEs exist. However, more research and innovative approaches are needed to avoid self-selection. In regard to waiting lists, new innovative game, and training formats have been proposed that allow more players to participate (Hintermann et al., under review; Rüeger et al., 2020). During selection procedures, time points for tiers of selective representation should be delayed to post-maturation (Cobley et al., 2020). If these selections are absolutely needed, individual data can be adjusted to normal growth curves or compared with corrective adjustment procedures (CAPs) to interpret interindividual differences in performance (Votteler and Honer, 2014; Romann and Cobley, 2015; Cobley et al., 2020). Furthermore, rather than testing physical parameters, more technical and tactical competences should be tested, as they reduce RAEs and show higher prognostic validity for the transition from youth to elite adult football (Höner and Feichtinger, 2016). An improvement of the psycho-social climate that emphasizes "personal learning and development" and longer-term tracking of athletes beyond maturation have been recommended to avoid RAE-related dropouts (Cobley et al., 2014).

Methodological Considerations

This study has several limitations. Firstly, this study simply examines RAEs in Swiss soccer during the 2018/2019 season, which is not necessarily a reflection of the general situation over a longer period of time. Secondly, the data did not include specific match-based values (e.g., the number of matches played). Such data may provide a more complete picture of RAEs (Coelho et al., 2010). Nevertheless, this is the first study to include the complete nationwide database of both sexes across all age categories and selection levels. Therefore, this study highlights the origins of RAEs and how different selections influence the evolution of RAEs in youth soccer. Future research should address how waiting lists could be avoided and how relative age influences talent development pathways of athletes in the long run.

CONCLUSION

RAEs have a small but consistent effect on participation in Swiss children's football at the grassroots level. The effect is highest at entry level and decreases from U8 to U20. Contrary to expectations, no inverse RAEs were found on the waiting lists. As U8 is the first possible club entry, RAEs could partly originate from self-selection. Nonetheless, clubs using a selection system seem to increase RAEs. The first-time coach selection at the grassroots level is the origin of RAEs and increases the magnitude of RAEs during following selection processes. To protect young athletes from discrimination, RAE biases should be analyzed and eliminated at all stages of sport participation, selection, and dropout situations. Modifications to the organizational structure of sport and athlete development systems are recommended to prevent RAE-related inequalities.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the ethics review board of the Swiss Federal Institute of Sport Magglingen. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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REFERENCES

Balish, S. M., McLaren, C., Rainham, D., Blanchard, C. (2014). Correlates of youth sport attrition: a review and future directions. *Psychol. Sport Exerc.* 15, 429–39. doi: 10.1016/j.psychsport.2014.04.003

Bergeron, M. F., Mountjoy, M., Armstrong, N., Chia, M., Côté, J., Emery, C. A., et al. (2015). International olympic committee consensus statement on youth athletic development. *Br. J. Sports Med.* 49, 843–851. doi: 10.1136/bjsports-2015-094962

Cobley, S., Abbott, S., Moulds, K., Hogan, C., and Romann, M. (2020). "Re-balancing the relative age effect scales: meta-analytical trends, causes, and corrective adjustment procedures as a solution," in *Relative Age Effects in Sport*, eds J. Dixon, S. Horton, L. Chittle, and J. Baker (New York, NY: Routledge), 136–153. doi: 10.4324/9781003030737-11

Cobley, S., Baker, J., Wattie, N., and Mckenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S. P., and Till, K. (2017). Participation trends according to relative age across youth UK rugby league. *Int. J. Sports Sci. Coach.* 12, 339–343. doi: 10.1177/1747954117710506

Cobley, S. P., Till, K., O'hara, J., Cooke, C., and Chapman, C. (2014). Variable and changing trajectories in youth athlete development: further verification in advocating a long-term inclusive tracking approach. *J. Strength Condition. Res.* 28, 1959–1970. doi: 10.1519/JSC.0000000000000353

Coelho, E. S. M. J., Figueiredo, A. J., Simoes, F., Seabra, A., Natal, A., Vaeyens, R., et al. (2010). Discrimination of u-14 soccer players by level and position. *Int. J. Sports Med.* 31, 790–796. doi: 10.1055/s-0030-1263139

Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C., and Malina, R. M. (2017). Bio-banding in sport: applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength Condition. J.* 39, 34–47. doi: 10.1519/SSC.0000000000000281

Delorme, N., Boiché, J., and Raspaud, M. (2010). Relative age and dropout in French male soccer. *J. Sports Sci.* 28, 717–722. doi: 10.1080/02640411003663276

Delorme, N., Chalabaev, A., and Raspaud, M. (2011). Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand. J. Med. Sci. Sports* 21, 120–128. doi: 10.1111/j.1600-0838.2009.01060.x

Delorme, N., and Raspaud, M. (2009). The relative age effect in young French basketball players: a study on the whole population. *Scand. J. Med. Sci. Sports* 19, 235–242. doi: 10.1111/j.1600-0838.2008.00781.x

Fraser-Thomas, J., Coté, J., and Deakin, J. (2008). Understanding dropout and prolonged engagement in adolescent competitive sport. *Psychol. Sport Exerc.* 9, 645–662. doi: 10.1016/j.psychsport.2007.08.003

Gibbs, B. G., Shafer, K., and Dufur, M. J. (2012). Why infer? The use and misuse of population data in sport research. *Int. Rev. Sociol. Sport*. 50, 115–121. doi: 10.1177/1012690212469019

Gil, S. M., Badiola, A., Bidaurrazaga-Letona, I., Zabala-Lili, J., Gravina, L., Santos-Concejero, J., et al. (2014). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *J. Sports Sci.* 32, 479–486. doi: 10.1080/02640414.2013.832355

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Höner, O., and Feichtinger, P. (2016). Psychological talent predictors in early adolescence and their empirical relationship with current and future performance in soccer. *Psychol. Sport Exerc.* 25, 17–26. doi: 10.1016/j.psychsport.2016.03.004

Hurley, W., Lior, D., and Tracze, S. (2001). A proposal to reduce the age discrimination in canadian minor hockey. *Can. Public Policy Anal. DE Polit.* 27, 65–75. doi: 10.2307/3552374

Jimenez, I. P., and Pain, M. T. G. (2008). Relative age effect in Spanish association football: its extent and implications for wasted potential. *J. Sports Sci.* 26, 995–1003. doi: 10.1080/02640410801910285

Kelly, A. L., Jackson, D. T., Taylor, J. J., Jeffreys, M. A., and Turnnidge, J. (2020). "Birthday-banding" as a strategy to moderate the relative age effect: a case study into the England squash talent pathway. *Front. Sports Act. Living.* 2:573890. doi: 10.3389/fspor.2020.573890

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Olivier, J., and Bell, M. L. (2013). Effect sizes for 2× 2 contingency tables. *PLoS ONE* 8:e58777. doi: 10.1371/journal.pone.0058777

Romann, M., and Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS ONE* 20:e0122988. doi: 10.1371/journal.pone.0122988

Romann, M., and Fuchslocher, J. (2011). Influence of the selection level, age and playing position on relative age effects in Swiss women's soccer. *Talent Dev. Excellence* 3, 239–247.

Romann, M., and Fuchslocher, J. (2013). Relative age effects in Swiss junior soccer and their relationship with playing position. *Eur. J. Sport Sci.* 13, 356–363. doi: 10.1080/17461391.2011.635699

Romann, M., and Fuchslocher, J. (2014). The need to consider relative age effects in women's talent development process. *Perceptual Motor Skills* 118, 1–12. doi: 10.2466/30.10.PMS.118k24w8

Romann, M., Rössler, R., Javet, M., and Faude, O. (2018). Relative age effects in Swiss talent development–a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–31. doi: 10.1080/02640414.2018.1432964

Rüeger, E., Hintermann, M., Kern, R., and Romann, M. (2020). Football des enfants : les barrières d'entrée dans les clubs. *Mobilesport*. Available online at: https://www.mobilesport.ch/football/football-des-enfants-les-barrieres-dentree-dans-les-clubs/

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–78. doi: 10.1007/s40279-018-0915-3

Swiss Federal Office of Statistics (2020). *Permanant Residential Population*. Bern. Available online at: http://www.bfs.admin.ch/bfs/portal/de/index/themen/01.html (accessed January 02, 2020).

Unicef (2018). *Children's Rights in Sport Principles*. Tokyo: UNICEF. Available online at: https://childinsport.jp/assets/downloads/Children%27s_Rights_in_Sport_Principles_English.pdf (accessed July 29, 2020).

Votteler, A., and Honer, O. (2014). The relative age effect in the German football TID programme: biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players. *Eur. J. Sport Sci.* 14, 433–442. doi: 10.1080/17461391.2013.837510

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

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Relative Age Effect in Elite German Soccer: Influence of Gender and Competition Level

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The relative age effect (RAE) is associated with (dis)advantages in competitive sports. While the RAE in elite male soccer reveals a skewed birthdate distribution in relation to a certain cut-off date, research of RAE in elite female soccer is affected by small number of samples and conflicting results. The purpose of this study was to investigate the RAE in elite adult German soccer regarding gender and competition level. The sample comprised 680 female and 1,083 male players of the two top German leagues during the 2019/20 season and German national teams (A-Team to Under 19). Differences between the observed and expected birthdate distributions were analyzed using chi-square statistics and effect sizes followed by calculating odds ratios. Results showed a statistically significant RAE with small effect size across all players included for both genders (female players: $P < 0.001$, $W = 0.16$, male players: $P < 0.001$, $W = 0.23$). The identified RAE was based on an over-representation of players born at the beginning of the year. According to gender and competition level, RAEs were more pronounced in German male soccer. While significant RAEs were found among males in the first two leagues (first league: $P < 0.001$, $W = 0.19$, second league: $P < 0.001$, $W = 0.26$), the RAE of females was more pronounced in the second league (first league: $P = 0.080$, $W = 0.16$, second league: $P = 0.002$, $W = 0.20$). The analysis of RAE regarding the national teams revealed a statistically significant RAE with large effect size for only the youngest investigated age group of male players (Under 19: $P = 0.022$, $W = 0.52$). Our data show an RAE in female and male German adult soccer, which could be accompanied by a loss of valuable elite players during the youth phase of the career. Consequently, the pool of talented players at the adult level would be limited.

Keywords: birthdate, season of birth, female, football, sex differences, talent selection, expertise, team sport

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INTRODUCTION

In sports, it has been shown that the relative age effect (RAE) favors relatively older athletes in terms of talent selection and development opportunities (Till et al., 2009). The term "relative age" refers to the difference in one's birthdate in relation to a cut-off date used to group children and adolescents (Smith et al., 2018). For example, in an age-based system with January 1st as a cut-off date,

Abbreviations: RAE, relative age effect; OR, odds ratio.

an individual born in January is almost 1 year older than an individual born in December. Because the RAE can lead to selection bias due to physical, cognitive, psychological and social attributes, it may be considered as discrimination against athletes who are born later within an age cohort (Simmons and Paull, 2001; Dixon et al., 2011). In light of the fact that selection bias in children and youth sports could lead to non-selection and dropout of talents, the long-term consequences for professional sports are obvious (Baker et al., 2010).

Review studies and meta-analyses show that there are various factors moderating the RAE in sport (Cobley et al., 2009; Baker et al., 2010; Sierra-Díaz et al., 2017; Smith et al., 2018). These include age, sport context, competition level, gender, and playing position. One of the most notable moderators of RAE appears to be gender (Baker et al., 2010), although a comprehensive study of the RAE shows little evidence for gender influences (Cobley et al., 2009). This outcome is most likely related to the fact that only 2% of all included athletes are female. Therefore, a recent meta-analysis examined the prevalence and magnitude of the RAE specifically in female athletes (Smith et al., 2018). The findings show a statistically significant, but small RAE across all sport contexts with the relatively older of the age cohort were 25% more likely to be represented. In addition, the competition level moderates the RAE significantly, but with inconsistent effects in elite adult athletes. Thus, a sport-specific analysis of the RAE could provide more insights into the competition level of elite female athletes.

In elite adult soccer, the influence of gender on the RAE is also affected by the small number of female samples and conflicting results (Vincent and Glamser, 2006; Baker et al., 2009; Delorme et al., 2009b; Romann and Fuchslocher, 2011; Sedano et al., 2015). For example, there is no statistically significant RAE in elite female soccer in the US Soccer Federation (Vincent and Glamser, 2006), French professional championship (Delorme et al., 2009b), or the Swiss national teams (Romann and Fuchslocher, 2011). However, other studies have found a significant RAE (Baker et al., 2009; Sedano et al., 2015). In contrast, a detailed examination of the birthdate distribution per quarter reveals differences between the studies in Spanish and US soccer. In elite male soccer, on the other hand, there are numerous analyses of the RAE (Barnsley et al., 1992; Verhulst, 1992; Helsen et al., 1998; Musch and Hay, 1999; Cobley et al., 2008; Ostapczuk and Musch, 2013; Brustio et al., 2018; Yagüe et al., 2018; Kelly et al., 2020). Overall, these studies show a consistent RAE with an over-representation of players born at the beginning of their cohort year. Studies examining gender as a moderator of RAE in elite soccer with comparable female and male cohorts are rare and characterized by contradictory results. In U 18 European Championship, there is no significant difference in RAE between female and male players (Helsen et al., 2005). However, in US and Japanese soccer, there are gender differences of RAE due to a weaker skewed birthdate distribution in female players (Vincent and Glamser, 2006; Baker et al., 2009; Nakata and Sakamoto, 2012). More research is needed to investigate possible gender differences in elite adult soccer.

In Germany, soccer is a highly popular sport and the German Soccer Association has a high number of female (1,155,785) and male (6,016,151) members (German Soccer Association, 2019). The UEFA Club Coefficient shows that female and male German club teams are among the top three in the March Ranking 2020 (UEFA, 2020). Moreover, the national teams are ranked third in the aggregated women's and men's FIFA World Ranking (FIFA, 2019). To the best of our knowledge, no study has provided evidence of gender influences on the RAE in the highest competition levels from a leading soccer nation. Thus, this study aimed to investigate the RAE in female and male soccer players competing at the top two German leagues and German national teams (A-Team to Under (U) 19). Based on previous studies (Vincent and Glamser, 2006; Cobley et al., 2009; Schorer et al., 2009; Baker et al., 2010; Nakata and Sakamoto, 2012; Smith et al., 2018), it was hypothesized that there is an RAE in elite adult players, with the RAE being more prominent among males than females. Additionally, we assumed reduced RAE magnitudes on the highest competition level.

MATERIALS AND METHODS

Subjects

Our study included a total sample of 680 female and 1,083 male adult soccer players, competing at the top two German leagues during the season 2019/20. Additionally, female and male rosters of the German national teams [A-Team, U 21 (male only), U 20, and U 19] were considered. The female U 21 national team could not be included, because this team was not managed by the German Soccer Association during the investigation period.

Because the rosters of the national teams varied depending on the importance of the meeting, only the rosters of the past two major tournaments (FIFA World Cup and UEFA European Championship) dating back to the year 2015 were analyzed. This process is in line with a previous study (Romann and Fuchslocher, 2013). Player birthdates were collected from the official data center of the German Soccer Association (accessed 7th April 2020)[1]. Players listed twice in national championships (eight females playing in the first and second league) were assigned to the team in which they participated more frequently. Because all data were freely available from the internet, no approval by an Ethical Committee was required. **Table 1** gives an overview of the players included.

Classification of Relative Age

The birth month of each player was used to define the birth quarter and half-year distribution per semester. To calculate the RAE, the annual age groups were broken down into quartiles (Cobley et al., 2009) and half-year groups (Cobley et al., 2008). The cut-off date was defined as January 1st. Therefore, the year was divided into four quartiles: Q1 = January, February and March, Q2 = April, May and June, Q3 = July, August and September, Q4 = October, November and December. Furthermore, the year was divided into two semesters: S1 = January to June, S2 = July to

[1] https://datencenter.dfb.de/datencenter

TABLE 1 | Overview of the included female and male elite adult soccer players.

Gender	Subgroups	Competition level	Number of teams (N)	Number of players (N)	Mean chronological age and SD at the beginning of competition (years)
Female	1st League (Frauen-Bundesliga)	National Championship 2019/20	12	280	23.9 (4.2)
	2nd League (2. Frauen-Bundesliga)	National Championship 2019/20	14	400	21.0 (4.0)
	A-Team	FIFA Women's World Cup 2019 and UEFA Women's European Championship 2017	2	46	26.2 (3.3)
	U 20	FIFA U-20 Women's World Cup 2018 and FIFA U-20 Women's World Cup 2016	2	42	19.3 (0.9)
	U 19	UEFA U-19 Women's European Championship 2019 and FIFA U-19 Women's World Cup 2018	2	40	18.4 (0.6)
Male	1st League (Bundesliga)	National Championship 2019/20	18	540	25.2 (4.5)
	2nd League (2. Bundesliga)	National Championship 2019/20	18	543	25.2 (4.2)
	A-Team	FIFA World Cup 2018 and UEFA European Championship 2016	2	46	26.5 (3.4)
	U 21	UEFA U-21 European Championship 2019 and UEFA U-21 European Championship 2017	2	46	22.3 (0.9)
	U 20	FIFA U-20 World Cup 2017 and FIFA U-20 World Cup 2015	2	42	20.0 (0.3)
	U 19	UEFA U-19 European Championship 2017 and UEFA U-19 European Championship 2016	2	36	19.1 (0.3)

U, under; SD, standard deviation.

December. The observed birthdate distributions of all players were calculated four each quarter and semester. The expected birthdate distribution was calculated gender- and age-specifically (female age group: 1983–2003, male age group: 1978–2002) from the corresponding reference population of births in Germany and served as control (Delorme and Champely, 2015). These birthdate statistics were also publically available on the internet (Statistisches Bundesamt, 2020).

Statistical Analyses

Chi-square goodness-of-fit tests were used to compare the observed and expected birthdate distributions. To determine subgroup differences, odds ratios (ORs) and 95% confidence intervals were calculated. The Chi-square goodness-of-fit tests were used to detect whether or not the assigned quartile of birth profile for a given sample was significantly different to an expected distribution (females: Q1 = 24.8%, Q2 = 24.8%, Q3 = 26.5%, Q4 = 23.9%, males: Q1 = 24.8%, Q2 = 25.0%, Q3 = 26.4%, Q4 = 23.9%). The ORs were calculated to test the odds of the frequency of a quarter/semester to another (Q1–Q3 vs. Q4, S1 vs. S2), whereby the Q4/S2 (relative youngest) functioned as the reference. An OR of 1.00 indicated that the frequency is equal in both quarters/semesters, while an OR of 2.00 indicated that the frequency of one quarter/semester is twice as high compared to the other (Smith et al., 2018).

Furthermore, effect sizes (Cohen's W) were calculated to determine the magnitudes of the chi-square tests. According to Cohen (1988), $W = 0.10$, $W = 0.30$, and $W = 0.50$ indicated a small, medium, and large effect, respectively. An alpha level of $P < 0.05$ was set for statistical significance. All statistical analyses were computed with a statistical software package (SPSS, version 23.0, SPSS Inc. Chicago, IL, United States).

RESULTS

The birthdate distribution by quarter for each female and male subgroup is shown in **Table 2**. There was a statistically significant RAE for the subgroup of all female and male players with small effect sizes [all female players: X^2 (3, N = 808) = 20.82, $P < 0.001$, $W = 0.16$, all male players: X^2 (3, N = 1,253) = 68.42, $P < 0.001$, $W = 0.23$]. Players born at the beginning of the year were over-represented (all female players: Q1 vs. Q4, *OR* = 1.49, all male players: Q1 vs. Q4, *OR* = 2.00, **Table 3**) and the ORs declined for the comparisons later in the year with Q4 being inferior in each case (all female players: Q2 vs. Q4, *OR* = 1.18, Q3 vs. Q4, *OR* = 1.08, all male players: Q2 vs. Q4, *OR* = 1.56, Q3 vs. Q4, *OR* = 1.44).

Regarding the influence of gender, the half-year distribution of birthdates of all included players revealed higher OR of S1 vs. S2 for males than for females (*OR* = 1.46 vs. 1.28, **Table 3**). With the exception of the U 20 national team, males also had higher ORs of S1 vs. S2 compared to females for the respective competition level (first league: *OR* = 1.37 vs. 1.24, second league: *OR* = 1.44 vs. 1.31, A-Team: *OR* = 1.56 vs. 1.09, U 20: *OR* = 1.80 vs. 2.00, U 19: *OR* = 3.00 vs. 1.00). The OR of S1 vs. S2 for the reference population was 0.99 and 0.98 for males and females, respectively.

Analyzing the competition level of male players, the first two leagues of national championship showed significant RAEs with small effect sizes [first league: X^2 (3, N = 540) = 20.50, $P < 0.001$, $W = 0.19$, second league: X^2(3, N = 543) = 36.44, $P < 0.001$, $W = 0.26$]. In both leagues, players born during the first half of the year were over-represented (first league: *OR* = 1.37, second league: *OR* = 1.44), while the OR of Q1 vs. Q4 indicated a higher frequency of relatively older players in the second league (*OR* = 1.92) compared to the first league (*OR* = 1.83). In addition, the analyzed male U 19 national teams revealed a significant RAE

TABLE 2 | Birthdate distribution of the female and male elite adult soccer players compared to the corresponding reference population.

	Category	Q1	Q2	Q3	Q4	Total	X^2	*P*	Cohen's W	Effect
Female	RP (1983–2003)	2,037,237	2,040,780	2,181,311	1,968,470	8,227,798				
	(%)	24.8	24.8	26.5	23.9					
	1st League	83	72	57	68	280	6.75	0.080	0.16	Small
	(%)	29.6	25.7	20.4	24.3					
	2nd League	131	96	98	75	400	15.34	**0.002**	0.20	Small
	(%)	32.8	24.0	24.5	18.8					
	A-Team	13	11	9	13	46	1.44	0.697	0.18	Small
	(%)	28.3	23.9	19.6	28.3					
	U 20	14	14	7	7	42	4.92	0.178	0.34	Medium
	(%)	33.3	33.3	16.7	16.7					
	U 19	12	8	13	7	40	2.04	0.565	0.23	Small
	(%)	30.0	20.0	32.5	17.5					
	All players	253	201	184	170	808	20.82	**<0.001**	0.16	Small
	(%)	31.3	24.9	22.8	21.0					
Male	RP (1978–2002)	2,597,318	2,619,274	2,763,735	2,507,238	10,487,565				
	(%)	24.8	25.0	26.4	23.9					
	1st League	161	151	140	88	540	20.50	**<0.001**	0.19	Small
	(%)	29.8	28.0	25.9	16.3					
	2nd League	194	126	122	101	543	36.44	**<0.001**	0.26	Small
	(%)	35.7	23.2	22.5	18.6					
	A-Team	17	11	12	6	46	5.04	0.169	0.33	Medium
	(%)	37.0	23.9	26.1	13.0					
	U 21	18	12	10	6	46	6.48	0.090	0.38	Medium
	(%)	39.1	26.1	21.7	13.0					
	U 20	16	11	10	5	42	5.66	0.129	0.37	Medium
	(%)	38.1	26.2	23.8	11.9					
	U 19	13	14	6	3	36	9.59	**0.022**	0.52	Large
	(%)	36.1	38.9	16.7	8.3					
	All players	419	325	300	209	1,253	68.42	**<0.001**	0.23	Small
	(%)	33.4	25.9	23.9	16.7					

Q, quarter; RP, reference population. Bold = statistically significant at $P < 0.05$.

TABLE 3 | Odds ratios of the birthdate distribution for the female and male elite adult soccer players.

	Category	OR comparisons, Q1–4 and S1–2 (95 % CI)			
		Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	S1 vs. S2
Female	RP (1983–2003)	1.04 (1.03–1.04)	1.04 (1.03–1.04)	1.11 (1.11–1.11)	0.98 (0.98–0.99)
	1st League	1.22 (0.77–1.94)	1.06 (0.66–1.70)	0.84 (0.52–1.36)	1.24 (0.89–1.73)
	2nd League	1.75 (1.18–2.60)	1.28 (0.85–1.93)	1.31 (0.87–1.97)	1.31 (0.99–1.73)
	A-Team	1.00 (0.33–3.03)	0.85 (0.27–2.63)	0.69 (0.22–2.23)	1.09 (0.48–2.47)
	U 20	2.00 (0.58–6.87)	2.00 (0.58–6.87)	1.00 (0.26–3.82)	2.00 (0.83–4.83)
	U 19	1.71 (0.48–6.17)	1.14 (0.30–4.37)	1.86 (0.52–6.61)	1.00 (0.42–2.40)
	All players	1.49 (1.13–1.96)	1.18 (0.89–1.57)	1.08 (0.81–1.44)	1.28 (1.05–1.56)
Male	RP (1978–2002)	1.04 (1.03–1.04)	1.05 (1.04–1.05)	1.10 (1.10–1.11)	0.99 (0.99–0.99)
	1st League	1.83 (1.29–2.60)	1.72 (1.20–2.45)	1.59 (1.11–2.28)	1.37 (1.08–1.74)
	2nd League	1.92 (1.37–2.69)	1.25 (0.88–1.78)	1.21 (0.85–1.72)	1.44 (1.13–1.82)
	A-Team	2.83 (0.83–9.67)	1.83 (0.51–6.60)	2.00 (0.56–7.09)	1.56 (0.68–3.56)
	U 21	3.00 (0.88–10.18)	2.00 (0.56–7.09)	1.67 (0.46–6.06)	1.88 (0.81–4.33)
	U 20	3.20 (0.86–11.81)	2.20 (0.57–8.47)	2.00 (0.51–7.80)	1.80 (0.75–4.32)
	U 19	4.33 (0.91–20.60)	4.67 (0.99–22.03)	2.00 (0.38–10.58)	3.00 (1.11–8.14)
	All players	2.00 (1.60–2.52)	1.56 (1.23–1.97)	1.44 (1.13–1.82)	1.46 (1.25–1.71)

Q, quarter; S, semester; RP, reference population; OR, odds ratio; CI, confidence interval.

with a large effect size [$X^2(3, N = 36) = 9.59$, $P = 0.022$, $W = 0.52$]. Again, players born during the first half of the year were over-represented (S1 vs. S2, $OR = 3.00$). No significant RAEs were identified for the A-Team ($P = 0.169$), the U 21 ($P = 0.090$), or the U 20 team ($P = 0.129$).

Regarding the competition level of female players, there was only a significant RAE in the subgroup of the second league of the national championship with a small effect size [$X^2(3, N = 400) = 15.34$, $P = 0.002$, $W = 0.20$]. A comparison of births over the half-year distribution showed an over-representation of the first 6 months for second league players (S1 vs. S2, $OR = 1.31$). Also, an OR of 1.75 of the comparison between Q1 vs. Q4 indicated that relatively older players of the second league were more likely to be represented. For all other female subgroups (first league and national teams), no statistically significant RAE was found ($P \geq 0.080$).

DISCUSSION

This study investigated the RAE in elite adult German soccer according to gender and competition level. Our main findings were: (a) There was a statistically significant RAE with small effect sizes across all included players for both genders, (b) the RAE was more prominent among males, and (c) while significant RAEs were found among males in the first two leagues, the RAE of females was more pronounced in the second league.

The overall RAE for all included soccer players showed that players born at the beginning of the year were consistently over-represented (**Tables 2**, **3**). This result is in line with the RAE of male players reported in several elite soccer leagues worldwide (Helsen et al., 1998, 2012; Musch and Hay, 1999; Salinero et al., 2013; Brustio et al., 2018; Rađa et al., 2018; Doyle and Bottomley, 2019; Lupo et al., 2019). For female players, it is, however, only partially consistent with the literature (Vincent and Glamser, 2006; Delorme et al., 2009b; Romann and Fuchslocher, 2011; Sedano et al., 2015). In this context, it is evident that the RAE can be influenced by various attributes such as physical, cognitive, psychological, and social aspects (Cobley et al., 2009; Dixon et al., 2011; Brustio et al., 2018; Kelly and Williams, 2020). In particular, physical attributes are more prominent in contact sports, like soccer, than in noncontact sports (Delorme et al., 2009b). In fact, it has recently been shown that power-associated capacities differ between different age and starting-nonstarting youth players (Hoppe et al., 2020). Therefore, a skewed birth distribution of elite adult players could be based on a selection bias in youth soccer (Simmons and Paull, 2001). With this in mind, relatively older youth players could be more frequently selected for talent development programs due to their possible advantages in anthropometric development and power capacities (Brustio et al., 2018; Kelly and Williams, 2020). In previous research, it was assumed that in addition to an average higher level of maturity, relatively older youth players also receive more competition time. These players may benefit from greater support in performance development than their relatively younger counterparts (Helsen et al., 2012), which may support our assumptions.

Regarding the influence of gender, the overall RAE was more prominent among males (**Table 2**). The literature shows inconsistent results in a gender-specific comparison of the RAE in soccer. For example, Helsen et al. (2005) identified no RAEs for female and male soccer players of the U 18 European Championship. To the contrary, Vincent and Glamser (2006) showed gender differences of the RAE of 17-year-old elite soccer players with an RAE in males, but not in females. Possible explanations for gender-specific differences of the RAE can be related to the level of attraction of a sport for girls and boys, country-specific differences, and variations of competition levels (Baker et al., 2010). When the comparison of gender differences in the RAE is extended to other team sports, some research suggests a greater RAE magnitude in males than in females (Baker et al., 2009; Schorer et al., 2009; Nakata and Sakamoto, 2012). One reason for this, and possibly also for our results, could be a less intense competition within a team to make the starting line-up (Musch and Grondin, 2001; Lupo et al., 2019). For example, in a less popular sport, the number of available athletes is reduced and the demand for positions is not as great (Schorer et al., 2009). Therefore, it is expected to have a smaller RAE when fewer athletes participate in the sport. Other explanations may include a reduced depth of competition and the interaction of maturational and biological differences with socialization effects (Vincent and Glamser, 2006; Baker et al., 2010; Nakata and Sakamoto, 2012). However, to elucidate these speculations, more studies are needed.

Regarding the competition level, the RAE was more pronounced at the second leagues, even though there were statistically significant differences among males in the first league (**Table 2**). Also, in US, English, Italian, and French soccer, several studies concluded that a higher competition level leads to a lower RAE (Baker et al., 2009; Delorme et al., 2009a; Fleming and Fleming, 2012; Brustio et al., 2018). This effect could be explained by the increased importance of technical, tactical, and psychological aspects at the elite level (Rampinini et al., 2009; Carling, 2013; Vestberg et al., 2020). For example, a performance analysis of the first league in German male soccer showed that the physical match running performance alone is not a key indicator for achieving success (Hoppe et al., 2015). Conversely, a more athletic competition style in the second league could influence the RAE. A higher injury rate in the second compared to the first league of German male soccer is may be an indirect indicator for the higher physical demands (Klein et al., 2019). At the level of individuals, another possible explanation could be the so-called "underdog" hypothesis (Gibbs et al., 2012), where the relatively younger players may benefit from more competitive play with relatively older players at young ages. This may help the relatively younger players to reach greater resiliency and coping skills at an elite adult level. For instance, there was a strong RAE within an English professional soccer academy, whereby relatively older players were three times more likely to be recruited compared to relatively younger players (Kelly et al., 2020). However, when analyzing the conversion rate, relatively younger players were four times more likely to achieve a professional contract once they have been selected for the academy. This is potentially achieved by overcoming major challenges in training and competition resulting in enhanced resilience (Kelly and Williams, 2020). Finally, in relation to the RAE of male players of the second league in our study, comparable results were obtained across the top five European second leagues in male soccer (Rađa et al., 2018). The authors attributed this observation to the fact that there is no second chance to enter the first league for late-born players.

Our findings in female players, namely that there was an RAE in the second but not in the first league, are partly in line with the literature. Similarly, in Spanish female soccer, a statistically significant RAE was found in second league players (Sedano et al., 2015). In contrast to our study, significant RAEs were also identified in the first Spanish league. In the US Soccer Federation (Vincent and Glamser, 2006) and the French professional championship (Delorme et al., 2009b), no significant RAEs were observed for females. One potential explanation for these discrepancies is that there are country-specific differences in the RAE of female soccer players, potentially due to different youth development and competition systems (Sierra-Díaz et al., 2017). For example, in German youth soccer, girls are allowed to compete with boys up to 16 years (German Soccer Association, 2020). This means that athletically stronger and presumably relatively older girls may be able to withstand this mixed-gender competition. In addition, in most German regional associations, it is allowed that girls of an older chronological age group can compete with boys of a younger chronological age group, which could intensify the RAE (Reinders, 2017).

A hypothetical explanation for the RAE of female second league players of our study could be due to structural reform. Starting with the 2018/19 season, the German second female soccer league was no longer divided into North and South. Instead, it was played in a single division with a reduced number of teams (German Soccer Association, 2017). This may has intensified the competition for making the team. Another potential reason could be the transition from youth to senior level (Lupo et al., 2019). Since the female youth players move directly to the senior leagues after the U 16/ U 17, we assumed that the likelihood of relatively older players making this transition is higher, at least in part, to the second league. The difference in the average age between the first and second league (first league 23.9 ± 4.2 years, second league: 21.0 ± 4.0 years, **Table 1**) suggests that more female youth players make the transition to the second league initially. Possible advantages of the physical maturation of relatively older players may be a cause of the RAE in the second league, at least researchers trace RAE in male athletes to this effect (Vincent and Glamser, 2006; Lupo et al., 2019). To clarify also these assumptions, more research is needed.

Our analysis of the RAE regarding the national teams only showed an over-representation of players born at the beginning of the year for the youngest investigated age group of male players (U 19). There is evidence that the RAE decreases with age after adolescence (Cobley et al., 2009; Brustio et al., 2018). For the German national male youth soccer teams, Skorski et al. (2016) also identified a decreasing RAE with increasing age categories from U 16 to the senior A-Team. The authors suspected that this phenomenon could be related to a higher proportion of relatively younger players achieving a professional level (Skorski et al., 2016). It is worth mentioning that for national teams the best players were selected. After adolescence, when the advantages of early physical maturity fade away and the best players all have a similar physiological level, technical-tactical skills, and cognitive abilities could make the difference to produce successful outcomes. This might enable relatively younger players be more competitive than their relatively older counterparts (McCarthy and Collins, 2014).

LIMITATIONS

Firstly, we did not record anthropometric and performance variables of the players, which may better describe the phenomenon of RAE. The discussion about physical advantages of players born close to the beginning of the age cohort is therefore somewhat speculative and thus more research is required. Secondly, the birthdates of players of national championships refer to only one season. This makes it difficult to draw conclusion about the development of an RAE over several seasons. Thirdly, we included national and international players of national championships, which could have an impact on the RAE magnitudes between the analyzed leagues (Schorer et al., 2009). Finally, the sample size in national teams is low. However, to solve that point, we grouped all players in a specific subgroup according to gender. In terms of statistics, we used the birth month of each player to define the birth quarter and half-year distribution per semester. It should be noted that this approach has, however, some limitations. For example, a player born on the 1st of January and a player born on the 31th of March are considered as equivalent. Decimal ranging or Poisson regression modeling could improve the sensitivity in quantifying the RAEs (Brustio et al., 2018; Gerdin et al., 2018; Doyle and Bottomley, 2019). Future studies should examine the influence of gender and competition level on the RAE in elite soccer over several seasons and possible causal factors of RAE such as physical maturation, anthropometric variables and individual performance for female and male players.

PRACTICAL IMPLICATIONS

Previous studies have made recommendations such as yearly rotation of the cut-off date (Romann and Fuchslocher, 2011), shifting the start of talent selection to the period after puberty (Güllich, 2014; Güllich and Emrich, 2014), and education of the long-term vision of coaches in the talent selection process (Yagüe et al., 2018), which may all aim to mitigate the negative consequences of the RAE. A pragmatic approach during scouting at junior competitions can be age-ordered shirt numbering, which reduces the selection bias associated with the RAE, and thus also long-term consequences of the overall quality of the top senior teams (Mann and van Ginneken, 2017). The transition from youth soccer to senior leagues is of particular importance for the career of a talented player. Considerable age differences can occur, especially in female soccer, which may induce a RAE. In flexible match schedules, players from the oldest junior and youngest senior age groups could be combined for competitions aiming to bridge the gap during the transition and could reduce the RAE.

CONCLUSION

In conclusion, our results demonstrate that RAEs exist in German elite adult female and male soccer. The statistically significant RAE of this study is based on an over-representation of players born at the beginning of the year. Considering the effect sizes and ORs, RAEs were more pronounced in males, although, similar effects were found among females in the second league. An RAE in adult soccer could be accompanied by a loss of valuable players during the youth phase of the career and limiting the pool of talented players at the adult level. In addition to explanations for the RAE in previous studies (Musch and Hay, 1999; Baker et al., 2009; Cobley et al., 2009; Helsen et al., 2012; Brustio et al., 2018; Smith et al., 2018), it is conceivable that the demanding transition from U 16/U 17 to the senior level of German female soccer intensify the RAE in this cohort. Coaches and practitioners should try to find solutions to assist players in the transition from youth to senior professional level. Depending on the organizational structures of the youth development system, flexible match schedules could possibly reduce the RAE of female players in this study.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://datencenter.dfb.de/datencenter provided by German Soccer Association.

AUTHOR CONTRIBUTIONS

MG and MH: conceptualization and investigation. MG: data curation, formal analysis, methodology, project administration, visualization, and writing—original draft. MH: supervision and writing—review and editing. Both authors contributed to the article and approved the submitted version.

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REFERENCES

Baker, J., Schorer, J., and Cobley, S. (2010). Relative age effects: an inevitable consequence of elite sport? *Sportwissenschaft* 40, 26–30. doi: 10.1007/s12662-009-0095-2

Baker, J., Schorer, J., Cobley, S., Bräutigam, H., and Büsch, D. (2009). Gender, depth of competition and relative age effects in team sports. *Asian J. Exerc. Sports Sci.* 6, 1–7.

Barnsley, R. H., Thompson, A. H., and Legault, P. (1992). Family planning: football style. The relative age effect in football. *Int. Rev. Sociol. Sport* 27, 77–87. doi: 10.1177/101269029202700105

Brustio, P. R., Lupo, C., Ungureanu, A. N., Frati, R., Rainoldi, A., and Boccia, G. (2018). The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. *PLoS One* 13:e0196253. doi: 10.1371/journal.pone.0196253

Carling, C. (2013). Interpreting physical performance in professional soccer match-play: should we be more pragmatic in our approach? *Sports Med.* 43, 655–663. doi: 10.1007/s40279-013-0055-8

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale: Lawrence Erlbaum Associates.

Delorme, N., Boiché, J., and Raspaud, M. (2009a). Relative age effect in female sport: a diachronic examination of soccer players: RAE in French female soccer. *Scand. J. Med. Sci. Sports* 20, 509–515. doi: 10.1111/j.1600-0838.2009.00979.x

Delorme, N., Boiché, J., and Raspaud, M. (2009b). The relative age effect in elite sport: the french case. *Res. Q. Exerc. Sport* 80, 336–344. doi: 10.1080/02701367.2009.10599568

Delorme, N., and Champely, S. (2015). Relative age effect and chi-squared statistics. *Int. Rev. Sociol. Sport* 50, 740–746. doi: 10.1177/1012690213493104

Dixon, J., Horton, S., and Weir, P. (2011). Relative age effects: implications for leadership development. *Int. J. Sport Soc.* 2, 1–15. doi: 10.18848/2152-7857/cgp/v02i02/54068

Doyle, J. R., and Bottomley, P. A. (2019). The relative age effect in European elite soccer: a practical guide to poisson regression modelling. *PLoS One* 14:e0213988. doi: 10.1371/journal.pone.0213988

FIFA (2019). *FIFA Women's Survey Report - Confederations & Global MAs*. Zurich: FIFA.

Fleming, J., and Fleming, S. (2012). Relative age effect amongst footballers in the English Premier League and English Football League, 2010-2011. *Int. J. Perform. Anal. Sport* 12, 361–372. doi: 10.1080/24748668.2012.11868604

Gerdin, G., Hedberg, M., and Hageskog, C.-A. (2018). Relative age effect in swedish male and female tennis players born in 1998–2001. *Sports* 6:38. doi: 10.3390/sports6020038

German Soccer Association (2017). *2. Frauen-Bundesliga ab 2018 Eingleisig*. Frankfurt: German Soccer Association.

German Soccer Association (2019). *Mitgliederstatistik 2019*. Frankfurt: German Soccer Association.

German Soccer Association (2020). *Jugendordnung*. Frankfurt: German Soccer Association.

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. *Int. Rev. Sociol. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Güllich, A. (2014). Selection, de-selection and progression in German football talent promotion. *Eur. J. Sport Sci.* 14, 530–537. doi: 10.1080/17461391.2013.858371

Güllich, A., and Emrich, E. (2014). Considering long-term sustainability in the development of world class success. *Eur. J. Sport Sci.* 14, S383–S397. doi: 10.1080/17461391.2012.706320

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., Van winckel, J., and Williams, A. M. (2012). The relative age effect in European professional soccer: did ten years of research make any difference? *J. Sports Sci.* 30, 1665–1671. doi: 10.1080/02640414.2012.721929

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *Am. J. Hum. Biol. Off. J. Hum. Biol. Assoc.* 10, 791–798. doi: 10.1002/(sici)1520-6300(1998)10:6<791::aid-ajhb10>3.0.co;2-1

Helsen, W. F., van Winckel, J., and Williams, A. M. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Hoppe, M., Slomka, M., Baumgart, C., Weber, H., and Freiwald, J. (2015). Match running performance and success across a season in german bundesliga soccer teams. *Int. J. Sports Med.* 36, 563–566. doi: 10.1055/s-0034-1398578

Hoppe, M. W., Barnics, V., Freiwald, J., and Baumgart, C. (2020). Contrary to endurance, power associated capacities differ between different aged and starting-nonstarting elite junior soccer players. *PLoS One* 15:e0232118. doi: 10.1371/journal.pone.0232118

Kelly, A. L., and Williams, C. A. (2020). Physical characteristics and the talent identification and development processes in male youth soccer: a narrative review. *Strength Cond. J.* 42, 15–34. doi: 10.1519/SSC.0000000000000576

Kelly, A. L., Wilson, M. R., Gough, L. A., Knapman, H., Morgan, P., Cole, M., et al. (2020). A longitudinal investigation into the relative age effect in an English professional football club: exploring the 'underdog hypothesis.'. *Sci. Med. Footb.* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Klein, C., Bloch, H., Burkhardt, K., Kühn, N., and Schäfer, M. (2019). *VBG-Sportreport 2019 – Analyse des Unfallgeschehens in den Zwei Höchsten Ligen der Männer: Basketball, Eishockey, Fußball, Handball. Eine Längsschnittbetrachtung drei Aufeinanderfolgender Spielzeiten*. Hamburg: VBG.

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2019.01465

Mann, D. L., and van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci.* 35, 784–790. doi: 10.1080/02640414.2016.1189588

McCarthy, N., and Collins, D. (2014). Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road? *J. Sports Sci.* 32, 1604–1610. doi: 10.1080/02640414.2014.908322

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Musch, J., and Hay, R. (1999). The relative age effect in soccer: cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociol. Sport J.* 16, 54–64. doi: 10.1123/ssj.16.1.54

Nakata, H., and Sakamoto, K. (2012). Sex differences in relative age effects among Japanese athletes. *Percept. Mot. Skills* 115, 179–186. doi: 10.2466/10.05.17.PMS.115.4.179-186

Ostapczuk, M., and Musch, J. (2013). The influence of relative age on the composition of professional soccer squads. *Eur. J. Sport Sci.* 13, 249–255. doi: 10.1080/17461391.2011.606841

Rađa, A., Padulo, J., Jelaska, I., Ardigò, L. P., and Fumarco, L. (2018). Relative age effect and second-tiers: no second chance for later-born players. *PLoS One* 13:e0201795. doi: 10.1371/journal.pone.0201795

Rampinini, E., Impellizzeri, F. M., Castagna, C., Coutts, A. J., and Wisløff, U. (2009). Technical performance during soccer matches of the Italian Serie A league: effect of fatigue and competitive level. *J. Sci. Med. Sport* 12, 227–233. doi: 10.1016/j.jsams.2007.10.002

Reinders, H. (2017). *Strukturelle Förderung des Mädchenfußballs: Rechtliche Regelungen zum Jahrgangsversetzten Einsatz von Juniorinnen im Junioren-Fußball in den Landesverbänden des DFB*. Würzburg: Schriftenreihe des Nachwuchsförderzentrums für Juniorinnen.

Romann, M., and Fuchslocher, J. (2011). Influence of the selection level, age and playing position on relative age effects in Swiss women's soccer. *Talent Dev. Excell.* 3, 239–247.

Romann, M., and Fuchslocher, J. (2013). Influences of player nationality, playing position, and height on relative age effects at women's under-17 FIFA World Cup. *J. Sports Sci.* 31, 32–40. doi: 10.1080/02640414.2012.718442

Salinero, J. J., Pérez, B., Burillo, P., and Lesma, M. L. (2013). Relative age effect in European professional football. Analysis by position. *J. Hum. Sport Exerc.* 8, 966–973. doi: 10.4100/jhse.2013.84.07

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., and Baker, J. (2009). Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scand. J. Med. Sci. Sports* 19, 720–730. doi: 10.1111/j.1600-0838.2008.00838.x

Sedano, S., Vaeyens, R., and Redondo, J. C. (2015). The relative age effect in Spanish female soccer players. Influence of the competitive level and a playing position. *J. Hum. Kinet.* 46, 129–137. doi: 10.1515/hukin-2015-0041

Sierra-Díaz, M., González-Víllora, S., Pastor-Vicedo, J., and Serra-Olivares, J. (2017). Soccer and relative age effect: a walk among elite players and young players. *Sports* 5:5. doi: 10.3390/sports5010005

Simmons, C., and Paull, G. C. (2001). Season-of-birth bias in association football. *J. Sports Sci.* 19, 677–686. doi: 10.1080/02640410152475801

Skorski, S., Skorski, S., Faude, O., Hammes, D., and Meyer, T. (2016). The relative age effect in elite German youth soccer: implications for a successful career. *Int. J. Sports Physiol. Perform.* 11, 370–376. doi: 10.1123/ijspp.2015-0071

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Statistisches Bundesamt (2020). *Lebendgeborene: Deutschland, Jahre, Geschlecht*. Atlanta, GA: Statistisches Bundesamt.

Till, K., Cobley, S., Wattie, N., O'Hara, J., Cooke, C., and Chapman, C. (2009). The prevalence, influential factors and mechanisms of relative age effects in UK rugby league: relative age effects in rugby league. *Scand. J. Med. Sci. Sports* 20, 320–329. doi: 10.1111/j.1600-0838.2009.00884.x

UEFA (2020). *UEFA Club Coefficients*. Nyon: UEFA.

Verhulst, J. (1992). Seasonal birth distribution of west European soccer players: a possible explanation. *Med. Hypothes.* 38, 346–348. doi: 10.1016/0306-9877(92)90030-G

Vestberg, T., Jafari, R., Almeida, R., Maurex, L., Ingvar, M., and Petrovic, P. (2020). Level of play and coach-rated game intelligence are related to performance on design fluency in elite soccer players. *Sci. Rep.* 10:9852. doi: 10.1038/s41598-020-66180-w

Vincent, J., and Glamser, F. D. (2006). Gender differences in the relative age effect among US olympic development program youth soccer players. *J. Sports Sci.* 24, 405–413. doi: 10.1080/02640410500244655

Yagüe, J. M., de la Rubia, A., Sánchez-Molina, J., Maroto-Izquierdo, S., and Molinero, O. (2018). The relative age effect in the 10 best leagues of male professional football of the Union of European Football Associations (UEFA). *J. Sports Sci. Med.* 17, 409–416.

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"He's Just a Wee Laddie": The Relative Age Effect in Male Scottish Soccer

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Significant structural, developmental, and financial constraints exist in Scottish soccer that may predicate a different approach to talent identification and development. To our knowledge, no published reports exist evaluating the prevalence of the relative age effect (RAE) in Scottish soccer players. Consequently, the aim of this study was to investigate the prevalence of the RAE among varied playing levels and ages of male Scottish youth soccer players. Birthdates of male youth players (n = 1,230) from U10 to U17 age groups and from playing levels: "Amateur" (n = 482), "Development" (n = 214), and "Performance" (n = 534), alongside a group of male Scottish senior professional players (n = 261) were recorded and categorized into quartiles (Q1 = January–March; Q2 = April–June; Q3 = July–September; and Q4 = October–December) and semesters (S1 = January–June and S2 = July–December) from the start of the selection year. Birthdates were analyzed for: (a) each playing level and (b) each age group irrespective of playing level. For the varied playing levels examined, an RAE was evident in "Development" and "Performance" playing levels only at youth level. When examining each age group, an RAE was observed in U12–U17 players only. While there was a slight asymmetry favoring Q1 born senior professional players, the RAE was not present within this group of our sample. Results from our study suggest that a bias in selecting individuals born earlier in the selection year may exist within male soccer academy structures, but not at amateur level. The asymmetry favoring chronologically older players at youth but not professional level questions the efficacy of this (un)conscious bias within male Scottish soccer players.

Keywords: RAE, adolescent, football, talent identification, development, selection, recruitment, Scotland

INTRODUCTION

The relative age effect (RAE) is a well-established asymmetry in birthdate distribution favoring those born earlier in the selection year for a given sport (Cobley et al., 2009; Hancock et al., 2013). Scientists propose that RAE bias could occur due to individuals born earlier in the selection year growing and maturing ahead of their peers when grouped by chronological age (Wattie et al., 2008; Malina et al., 2017). It is also suggested that RAE bias could exist due to social factors, such as an earlier engagement in sporting activities or (un)conscious judgments by coaches influenced by physical factors related to growth and maturation (Hancock et al., 2013; Wattie et al., 2014). Although progress in understanding and communicating the RAE has been made over recent years, the "win now" emphasis encompassing youth sport remains, particularly within soccer (Andronikos et al., 2016; Reeves et al., 2018a; Hill et al., 2019; Lupo et al., 2019; Jackson and Comber, 2020). This demand for immediate success has resulted in a maturation-selection phenomenon, whereby chronologically older players are preferred due to their superior physical qualities (Lovell et al., 2015; Johnson et al., 2017; Hill et al., 2019). Thus, chronologically younger players may be overlooked or deselected during the developmental stages of talent development (Meylan et al., 2010; Helsen et al., 2012).

Differences in birthdate distributions in youth soccer are evidenced between academy players and the general population. For example, when comparing birthdate distributions of U8 English Premier League academy players to U8 regional grassroots players, a prevalent RAE was observed; with 57% of academy players born in the first quartile (Q1) of the selection year comparative to 30% for amateur grassroots players (Jackson and Comber, 2020). Similarly, Doncaster et al. (2020) observed that 53% of male soccer players from the FC Barcelona academy were born in Q1, compared to Q1 population values for Spain of 24%. An asymmetry in birthdate distribution favoring those born in either Q1 or the first semester (S1) of a selection year appears to be consistent within all age groups within professional soccer academies (Del Campo et al., 2010; Lovell et al., 2015), but not in amateur players (le Gall et al., 2010; Jackson and Comber, 2020). The magnitude of RAE in youth soccer tends to decrease with advancing chronological age, with authors observing the largest discrepancies in birth quartile distributions in comparatively young age groups (Helsen et al., 1998, 2000; Carling et al., 2009). Although not associated with physical growth and maturity factors at this stage, the RAE is proposed to be at its most influential within talent identification and (de)selection processes for pre-adolescent players (Lovell et al., 2015). Thereafter, biological maturation may further differentiate this already established asymmetry in birthdate distribution, cascading across the developmental process as exposure to systematic talent development grants them advanced coaching, competition, and facilities (Cobley et al., 2009; Lovell et al., 2015).

The prevalence of the RAE often continues into senior professional soccer succeeding any physical or biological advantages. For example, the RAE was evident in 9 out of 10 of the best leagues of the Union of European Football Associations (UEFA) during the 2016–2017 season (Yagüe et al., 2018). The RAE bias may transfer to professional levels due to the prevalence of birthdate asymmetry within the youth academy selection pool (Jimenez and Pain, 2008; Figueiredo et al., 2009). However, suggestions that the RAE diminishes as age increases and players transition to professional level, have been frequently reported (Mujika et al., 2009; González-Víllora et al., 2015; Skorski et al., 2016; Brustio et al., 2018; Gil et al., 2020). Considering the overrepresentation of chronologically older players at youth level, this reduction in prevalence of the RAE at senior professional levels challenges the efficacy of this (un) conscious bias.

It has been suggested that talented youth players not favored by the RAE bias (i.e., Q3/Q4 or S2 born) may be required to demonstrate superior technical and psychological skills to endure (de)selection during academy soccer (Cumming et al., 2018a; Patel et al., 2019). Consequently, when approaching senior professional transition, these superior abilities elevate these chronologically younger players due to the diminishing physical and developmental advantages previously benefitting their chronologically older peers (Votteler and Höner, 2014; Cumming et al., 2018b). Differing approaches to talent identification and (de)selection have been observed in soccer, largely influenced by the varied philosophies and perceived competition demands of the nation or league observed (Carling et al., 2012; Unnithan et al., 2012; Reeves et al., 2018b). Therefore, although there is evidence that the RAE is a global bias within the sport of soccer, it is logical to assume that its prevalence may vary dependent on the nation, and the under-pinning soccer philosophy of the club or nation, and competitive level examined.

Established soccer nations are highly successful at international level and often possess large talent pools, substantial participation rates, considerable financial and logistical resources, and strong domestic competition (Bennett et al., 2018). Comparatively, emerging soccer nations may be contrasting in these observations. When examining talent identification in soccer, the extant literature has largely focused on established nations (Figueiredo et al., 2009; le Gall et al., 2010; Carling et al., 2012; Unnithan et al., 2012; Reeves et al., 2018b). As a consequence, established soccer nations have made marked progress in identifying and addressing confounding factors of talent identification in soccer, whereas emerging nations may be limited due to the aforementioned discrepancies (Bennett et al., 2018). These limitations may result in a different approach to talent identification and development being adopted, and highlight the requirement for further investigation on confounding factors of talent identification and (de)selection in emerging soccer nations.

Despite high participation rates, an established national federation, and societal similarities to the rest of the United Kingdom, Scotland's soccer success at both club and international levels has been hindered, potentially due to financial and developmental constraints (Morrow, 2006; Adams et al., 2017). Furthermore, Scotland has only recently implemented a systematic performance strategy, providing a framework for talent identification and development of youth players (SFA, 2017). Acknowledging these constraints, approaches to talent identification and development within Scottish soccer may not be comparable to published reports from the rest of the United Kingdom and Europe, and more in line with those of emerging soccer nations (Bennett et al., 2018). To our knowledge, no published reports exist that examine the prevalence of RAE in Scottish soccer players, and only one study reports on the RAE for a smaller, emerging soccer nation (Finnegan et al., 2017).

Therefore, the aim of this study was to assess the prevalence of the RAE in male Scottish youth soccer players across all ages and playing standards within the Scottish Football Association (SFA) National Governing Body infrastructure, compared to a reference group of male Scottish professional players. We examine birthdate distributions across quartiles and semesters for: (a) varied playing levels at youth (amateur, development, and performance) and in Scottish senior professional players and (b) each age group at youth (U10–U17), irrespective of playing level. It was hypothesized that the prevalence of the RAE would increase in-line with the playing standard classifications, but would be less apparent for senior professional players compared to youth. It was also hypothesized that the RAE would be most prevalent in younger players within our sample, cascading but gradually decreasing as players become older and physical and biological advantages diminish. These findings have the potential to provide insights for other, smaller countries that may not be comparable to more established soccer nations captured by the extant RAE literature.

MATERIALS AND METHODS

Participants and Procedures

Birthdates of 1,230 male youth soccer players aged 9–17 years were obtained in February, 2020. Players were categorized into age groups: U10 (n = 54); U11 (n = 140); U12 (n = 164); U13 (n = 176); U14 (n = 192); U15 (n = 206); U16 (n = 180); and U17 (n = 118), and playing levels: amateur (recreational players, n = 482); development (lower ranked professional academies, n = 214); and performance (junior-elite academies, n = 534) as specified by the SFA (SFA, 2017). Birthdates were also obtained for 261 Scottish professional soccer players aged 17–38 years *via* Wyscout (Chiavari, Italy) in February, 2020. Professional players had competed in either the English Premiership, English Championship, or Scottish Premiership in the 12 months prior to data collection. The study received institutional ethical approval from the local University ethics committee.

Statistical Analyses

Birthdates for all players were categorized into the following relative age quartiles: Q1 = January–March; Q2 = April–June; Q3 = July–September; and Q4 = October–December, and semesters: S1 = January–June and S2 = July–December from the start of the selection year specified by the SFA, and were reported as frequencies and percentages (%). The Chi squared (χ^2) test was used to assess differences between observed and expected birthdate distributions across quartiles for: (a) each playing level and (b) each age group, irrespective of playing level. Expected birthdates were obtained from the National Records of Scotland and reflected average population birthdate distributions 1981–2010, capturing population records for the birth years from the oldest to the youngest players within our sample. Population birthdate distributions were reported as 24.8, 24.9, 25.6, and 24.7% for Q1, Q2, Q3, and Q4, respectively. Odds ratios (ORs) and 95% confidence intervals (95% CI) were calculated to compare the birthdate distribution of a quartile (Q1, Q2, or Q3) or semester (S1) with a reference group, consisting of the relatively youngest players (Q4 or S2, respectively). ORs were considered significant if the 95% CI range did not include a value ≤1.0. Data were analyzed *via* SPSS Statistics Version 25.0 for Windows (IBM, Chicago, Illinois, United States). Where appropriate, the alpha level was set at $p < 0.05$.

RESULTS

The frequency and percentage distributions of players' birth quartiles for each playing level are presented in **Table 1**. Within the "Amateur," "Development," and "Performance" groups, players born in Q1 represented the largest quartile distribution across all playing levels, with a progressive decline to Q4. OR analyses revealed that an RAE existed within "Development" and "Performance" player groups, but not within the "Amateur" player group. The Chi-squared test demonstrated significant deviations across birth quartiles for "Development" and "Performance" groups only. For "Professional" players, players born in Q1 represented the largest quartile distribution; however, a progressive decline from Q1 to Q4 was not observed for this group. OR analyses revealed that an RAE did not exist for Scottish "Professional" players, and the Chi-squared test was not significant for this group.

The frequency and percentage distributions of players' birth quartiles for each age group are presented in **Table 2**. For U10 and U11 player groups, the largest quartile distributions were observed in Q4 (29.6%) and Q3 (32.9%), respectively. However, this did not reach statistical significance. Players born in Q1 represented the largest birth quartile distribution for U12–U17 player groups (35.4–49.2%). For U12–U17 player groups, a progressive decline from Q1 to Q4 was observed. OR analyses revealed that an RAE existed across U12–U17 player groups, however, was highest for U17 players. The Chi-squared test demonstrated significant deviations across birth quartiles for U12–U17 groups only.

DISCUSSION

Considering the financial and developmental constraints facing Scottish soccer, combined with a paucity of published reports for smaller and emerging soccer nations, we explored the prevalence of the RAE among varied playing levels and ages of male Scottish soccer players. When examining the influence of playing level on the prevalence of the RAE in our sample, our results indicate that the RAE was evident in "Development" and "Performance" groups only. We also observed that the RAE was only prevalent in U12–U17 players, with no apparent RAE for U10–U11 players in our sample. Finally, while there was a slight asymmetry favoring Q1 born professional players, the RAE was not present within this group of our sample.

TABLE 1 | Birth quartile distributions by playing level.

		Birthdate distribution (%)				Odds ratio (95% CI)				Chi-squared
Playing level	***n***	**Q1**	**Q2**	**Q3**	**Q4**	**Q1 vs. Q4**	**Q2 vs. Q4**	**Q3 vs. Q4**	**S1 vs. S2**	χ^2
Amateur	482	152 (31.5)	132 (27.4)	114 (23.7)	84 (17.4)	1.8 (0.8–4.1)	1.6 (0.7–3.6)	1.4 (0.6–3.1)	1.4 (0.8–2.5)	4.4
Development	214	92 (43.0)	50 (23.4)	40 (18.7)	32 (15.0)	2.9 (1.3–6.5)	1.6 (0.7–3.7)	1.3 (0.5–3.0)	2.0 (1.1–3.5)	19.1*
Performance	534	216 (40.5)	160 (30.0)	98 (18.4)	60 (11.2)	3.6 (1.5–8.5)	2.7 (1.1–6.4)	1.6 (0.7–4.1)	2.4 (1.3–4.3)	20.4*
Professional	261	76 (29.1)	56 (21.5)	65 (24.9)	64 (24.5)	1.2 (0.6–2.6)	0.9 (0.4–2.0)	1.0 (0.5–2.2)	1.0 (0.6–1.8)	1.2

*Q1, January–March; Q2, April–June; Q3, July–September; Q4, October–November. *Significant at an alpha level of p < 0.05.*

TABLE 2 | Birth quartile distributions by age group.

		Birthdate distribution (%)				Odds ratio (95% CI)				Chi-squared
Age group	***n***	**Q1**	**Q2**	**Q3**	**Q4**	**Q1 vs. Q4**	**Q2 vs. Q4**	**Q3 vs. Q4**	**S1 vs. S2**	χ^2
U10	54	12 (22.2)	16 (26.6)	10 (18.5)	16 (29.6)	0.8 (0.3–1.6)	1.0 (0.5–2.1)	0.6 (0.3–1.4)	1.1 (0.6–1.9)	3.3
U11	140	24 (17.1)	32 (22.9)	46 (32.9)	38 (27.1)	0.6 (0.3–1.4)	0.8 (0.4–1.9)	1.2 (0.6–2.6)	0.7 (0.4–1.2)	4.9
U12	164	58 (35.4)	50 (30.5)	38 (23.2)	18 (11.0)	3.2 (1.3–7.7)	2.8 (1.2–6.7)	2.1 (0.9–5.2)	1.9 (1.1–3.4)	13.6*
U13	176	78 (44.3)	56 (31.8)	20 (11.4)	22 (12.5)	3.6 (1.5–8.2)	3.6 (1.1–6.0)	0.9 (0.3–2.4)	3.2 (1.7–5.8)	31.2*
U14	192	84 (43.8)	40 (20.8)	38 (19.8)	30 (15.6)	2.8 (1.3–6.2)	1.3 (0.6–3.2)	1.3 (0.5–3.0)	1.8 (1.0–3.2)	19.9*
U15	206	82 (39.8)	68 (33.0)	34 (16.5)	22 (10.7)	3.7 (1.6–8.9)	3.1 (1.3–7.5)	1.6 (0.6–4.0)	2.7 (1.5–4.8)	22.9*
U16	180	64 (35.6)	52 (28.9)	44 (24.4)	20 (11.1)	3.2 (1.3–7.7)	2.6 (1.1–6.3)	2.2 (0.9–5.4)	1.8 (1.0–3.2)	12.9*
U17	118	58 (49.2)	28 (23.7)	22 (18.6)	10 (8.5)	5.8 (2.3–14.5)	2.8 (1.1–7.3)	2.2 (0.8–5.9)	2.7 (1.5–4.9)	36.6*
Professional	261	76 (29.1)	56 (21.5)	65 (24.9)	64 (24.5)	1.2 (0.6–2.6)	0.9 (0.4–2.0)	1.0 (0.5–2.2)	1.0 (0.6–1.8)	1.2

*Q1, January–March; Q2, April–June; Q3, July–September; Q4, October–November. *Significant at an alpha level of p < 0.05.*

The finding that an RAE was particularly pronounced in youth academy soccer players ("Development" and "Performance"), compared to recreational players ("Amateur"), confirms our hypothesis and is consistent with previous reports (Del Campo et al., 2010; Lovell et al., 2015; Hill et al., 2019). It is widely proposed that physical factors associated with growth and maturation may influence talent identification and (de)selection decisions within academy soccer (Vaeyens et al., 2005; Wattie et al., 2008; Hancock et al., 2013), leading to an overrepresentation of chronologically older players within these settings. Moreover, chronologically older players may acquire more practice time due to an earlier onset in sporting engagement and, therefore, may be more likely to be recruited due to advanced technical abilities (Hancock et al., 2013; Wattie et al., 2014). Published reports suggest that chronologically older players may be taller, heavier, and perform better at physical fitness tests compared to their younger counterparts (Figueiredo et al., 2009). In addition, physical factors may provide acute technical advantages for youth players during competition (Meylan et al., 2010). The absence of a prevalent RAE in the "Amateur" players within our study suggests that birthdate asymmetries may occur due to selection and competition pressures associated with academy soccer, which are alleviated at grassroots level (Wattie et al., 2008; Lupo et al., 2019; Jackson and Comber, 2020). Although youth academies aim to promote developmental strategies to maximize chances of youth-professional transition, an overreliance on success and performance in the short-term has likely influenced decision-making within this sample (Andronikos et al., 2016). Our data provide further support to the premise that chronologically older players are overrepresented within male academy soccer. We also suggest that (un)conscious bias may be influencing (de)selection processes within our sample similar to previous observations from established soccer nations.

We also hypothesized that the RAE would be most prevalent in younger players and gradually decrease as players become older and physical and biological advantages diminish. Although our data demonstrate an asymmetry in birthdate distribution during the adolescent years, the prevalence of an RAE did not decrease with age as anticipated. It is proposed that physical differences, influenced by growth and maturation, may be most pronounced during early- and mid-adolescence (Malina et al., 2017). Therefore, the maturation-selection phenomenon may explain the prevalence of an RAE within players aged ~12–15 years within our sample. The observation that a significant asymmetry in birthdate distribution persisted until U17, however, suggests that selection bias continues to favor chronologically older players despite diminishing physical advantages. This is indicative of the "cascade effect," suggesting a continuation of bias favoring chronologically older players during later years due to talent identification and (de)selection approaches during adolescence (Mujika et al., 2009; Lovell et al., 2015). Furthermore, this observation could be due to additional performance-related factors, such as technical ability or perceptual-cognitive skills, that may have been fostered during early recruitment and prolonged exposure to systematic talent development due to a birthdate advantage (Hancock et al., 2013; Wattie et al., 2014; Doncaster et al., 2020). Finally, we observed no RAE for U10–U11 players within our sample. This finding also supports the maturation-selection phenomenon, as evidence suggests that until the onset of adolescence, minimal differences in physical factors are evident between chronologically older and chronologically younger soccer players (Malina et al., 2010, 2012). We suggest that, comparative to previous reports, the asymmetry in birthdate distributions observed in our sample may be due to physical and biological factors influencing both (de)selection and participation from the onset of adolescence and cascading through to later years of youth soccer. However, our findings also support the notion that the RAE may extend beyond biological and physical advantages in sport, and that consideration to a wider array of potential factors contributing to the prevalence of the RAE should be prioritized (Hancock et al., 2013; Wattie et al., 2014; Doncaster et al., 2020).

Lastly, an RAE was not observed in our sample of male Scottish senior professional soccer players. This suggests that although the selection of chronologically older players seems to occur at youth levels, this approach may not translate to professional levels, thus questioning the efficacy of this (un)conscious bias. Although prevalence of an RAE have been previously reported for senior professional soccer players from established soccer nations (Helsen et al., 2012; Padrón-Cabo et al., 2016; Yagüe et al., 2018), these findings are ambiguous in nature and have been suggested to be dependent on the varied philosophies held by coaches or clubs, or by the perceived competition demands of the nation or league observed (Carling et al., 2012; Unnithan et al., 2012; Reeves et al., 2018b). Furthermore, the magnitude of birthdate asymmetries appears to reduce in established soccer nations between youth and professional levels (Mujika et al., 2009; González-Víllora et al., 2015; Skorski et al., 2016; Brustio et al., 2018; Lupo et al., 2019; Gil et al., 2020). Despite observing marked differences in RAE prevalence between academy and senior professional soccer players, these authors all report significant birthdate asymmetries at professional levels. Finally, considering that we observed the largest asymmetry in birthdate distribution for our U17 players, the age group before professional transition, it is possible that an RAE was prevalent in the early career phase of our professional players but reduced as players were (de)selected and progressed during their playing career, as previously observed (Lupo et al., 2019).

While we observed a slight asymmetry favoring Q1 born professional players, the RAE was not present within this group of our sample. This discrepancy between RAE prevalence in youth and professional players in our sample may support the notion that, over recent years, established soccer nations have made marked progress in identifying and addressing confounding factors of talent identification in soccer, whereas emerging and developing nations (which may be comparable to Scotland) may be limited due to financial, logistical, and competition limitations (Bennett et al., 2018). Furthermore, Scotland only recently implemented "Project Brave," a systematic performance strategy for youth academies, comparable to the English Premier League's Elite Player Performance Plan (The English Premier League, 2011), aligned to their philosophy and processes regarding long-term athlete development (SFA, 2017). Considering we observed a consistent RAE bias within our sample of Scottish academy soccer players, but not in Scottish senior professional players, could suggest that factors associated with birthdate advantages may have strongly influenced talent identification and (de)selection processes within Scotland during our data collection and prior to the inception of the SFA "Project Brave" Performance strategy in 2017. Resultant of this observation, we reiterate that acute physical advantages associated with birthdate advantages may not be representative of successful youth-professional transition, and their importance should be reconsidered during talent identification and talent development strategies.

This study is not without its limitations. Although we provide a comprehensive overview of birthdate distributions across multiple playing levels within organizational structures of male Scottish youth soccer, alongside a sample of male Scottish professional players, our sample is comparatively small considering previous examinations of RAE bias in soccer. However, we offer an investigation into a soccer nation that may not be comparable to the extant body of literature that focuses on established soccer nations, and suggest that this is considered in light of this limitation. Secondly, the absence of anthropometric and performance data is a further limitation of our study. As a consequence, our assumptions on the advantages associated with RAE biases, within our sample, are proposed upon their associations with chronologically older players rather than supported by original data. To progress this avenue of research further, future research should investigate talent identification and development structures in emerging and developing soccer nations, such as Scotland. Understanding these underlying mechanisms will allow progress to be made in reducing this bias and other confounding factors of (de) selection from youth soccer, and contribute toward a more systematic approach to talent identification and development.

CONCLUSION

Results from our study suggest that a bias in selecting individuals born earlier within the selection year exists within male Scottish academy soccer, but not at amateur or professional levels. This bias did not diminish as age increased within our sample of Scottish youth soccer players, and was not present in U10–U11 age groups. Finally, when examining each age group within each playing level, we observed a relatively consistent RAE within our sample. Considering our findings, we suggest that the RAE may be a relatively consistent issue throughout all playing levels and ages of male Scottish youth soccer. As previously reported, birthdate asymmetries are particularly pronounced within youth academy settings, and that physical and social factors related to the RAE are likely influencing decisions around talent identification development in Scottish soccer. We encourage coaches and recruiters to acknowledge the prevalence of the RAE in Scottish soccer and draw attention to the potential limitations and exclusive nature of chronological age banding in sport.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Stirling cross-faculty ethics committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JD, AM, and VU contributed to conception and design of the study. JD performed the data collection and wrote the first draft of the paper. JD and VU performed the data analysis. All authors contributed to manuscript revision and read and approved the submitted version.

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REFERENCES

Adams, A., Morrow, S., and Thomson, I. (2017). Changing boundaries and evolving organizational forms in football: novelty and variety among scottish clubs. *J. Sport Manag.* 31, 161–175. doi: 10.1123/jsm.2016-0286

Andronikos, G., Elumaro, A. I., Westbury, T., and Martindale, R. J. J. (2016). Relative age effect: implications for effective practice. *J. Sports Sci.* 34, 1124–1131. doi: 10.1080/02640414.2015.1093647

Bennett, K. J. M., Vaeyens, R., and Fransen, J. (2018). Creating a framework for talent identification and development in emerging football nations. *Sci. Med. Football* 3, 36–42. doi: 10.1080/24733938.2018.1489141

Brustio, P. R., Lupo, C., Ungureanu, A. N., Frati, R., Rainoldi, A., and Boccia, G. (2018). The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie a. *PLoS One* 13:e0196253. doi: 10.1371/journal.pone.0196253

Carling, C., Le Gall, F., and Malina, R. M. (2012). Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. *J. Sports Sci.* 30, 1683–1693. doi: 10.1080/02640414.2011.637950

Carling, C., Le Gall, F., Reilly, T., and Williams, A. M. (2009). Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players? *Scand. J. Med. Sci. Sports* 19, 3–9. doi: 10.1111/j.1600-0838.2008.00867.x

Cobley, S., Baker, J., Wattie, N., and Mckenna, J. (2009). Annual age-grouping and athlete development. A meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cumming, S. P., Brown, D. J., Mitchell, S., Bunce, J., Hunt, D., Hedges, C., et al. (2018a). Premier league academy soccer players' experiences of competing in a tournament bio-banded for biological maturation. *J. Sports Sci.* 36, 757–765. doi: 10.1080/02640414.2017.1340656

Cumming, S. P., Searle, C., Hemsley, J. K., Haswell, F., Edwards, H., Scott, S., et al. (2018b). Biological maturation, relative age and self-regulation in male professional academy soccer players: a test of the underdog hypothesis. *Psychol. Sport Exerc.* 39, 147–153. doi: 10.1016/j.psychsport.2018.08.007

Del Campo, D. G. D., Vicedo, J. C. P., Villora, S. G., and Jordan, O. R. C. (2010). The relative age effect in youth soccer players from Spain. *J. Sports Sci. Med.* 9, 190–198.

Doncaster, G., Medina, D., Drobnic, F., Gómez-Díaz, A. J., and Unnithan, V. (2020). Appreciating factors beyond the physical in talent identification and development: insights from the FC Barcelona sporting model. *Front. Sports Act. Living* 2:91. doi: 10.3389/fspor.2020.00091

Figueiredo, A. J., Gonçalves, C. E., Coelho-e-Silva, M. J., and Malina, R. M. (2009). Characteristics of youth soccer players who drop out, persist or move up. *J. Sports Sci.* 27, 883–891. doi: 10.1080/02640410902946469

Finnegan, L., Richardson, D., Littlewood, M., and McArdle, J. (2017). The influence of date and place of birth on youth player selection to a National Football Association elite development programme. *Sci. Med. Football* 1, 30–39. doi: 10.1080/02640414.2016.1254807

Gil, S. M., Bidaurrazaga-Letona, I., Martin-Garetxana, I., Lekue, J. A., and Larruskain, J. (2020). Does birth date influence career attainment in professional soccer? *Sci. Med. Football* 4, 119–126. doi: 10.1080/24733938.2019.1696471

González-Víllora, S., Pastor-Vicedo, J. C., and Cordente, D. (2015). Relative age effect in UEFA championship soccer players. *J. Hum. Kinet.* 47, 237–248. doi: 10.1515/hukin-2015-0079

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., van Winckel, J., and Williams, A. M. (2012). The relative age effect in European professional soccer: did ten years of research make any difference? *J. Sports Sci.* 30, 1665–1671. doi: 10.1080/02640414.2012.721929

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *Am. J. Hum. Biol.* 10, 791–798. doi: 10.1002/(SICI)1520-6300(1998)10:6<791::AID-AJHB10>3.0.CO;2-1

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (2000). Effect of a change in selection year on success in male soccer players. *Am. J. Hum. Biol.* 12, 729–735. doi: 10.1002/1520-6300(200011/12)12:6<729::aid-ajhb2>3.0.co;2-7

Hill, M., Scott, S., Malina, R. M., McGee, D., and Cumming, S. P. (2019). Relative age and maturation selection biases in academy football. *J. Sports Sci.* 38, 1359–1367. doi: 10.1080/02640414.2019.1649524

Jackson, R. C., and Comber, G. (2020). Hill on a mountaintop: a longitudinal and cross-sectional analysis of the relative age effect in competitive youth football effect in competitive youth football. *J. Sports Sci.* 38, 1352–1358. doi: 10.1080/02640414.2019.1706830

Jimenez, I. P., and Pain, M. (2008). Relative age effect in Spanish association football: its extent and implications for wasted potential. *J. Sports Sci.* 26, 995–1003. doi: 10.1080/02640410801910285

Johnson, A., Farooq, A., and Whiteley, R. (2017). Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci. Med. Football* 1, 157–163. doi: 10.1080/24733938.2017.1283434

le Gall, F., Carling, C., Williams, M., and Reilly, T. (2010). Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. *J. Sci. Med. Sport* 13, 90–95. doi: 10.1016/j.jsams.2008.07.004

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in English lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS One* 10:e0137238. doi: 10.1371/journal.pone.0137238

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2019.01465

Malina, R. M., Coelho-e-Silva, M. J., Figueiredo, A. J., Carling, C., and Beunen, G. P. (2012). Interrelationships among invasive and noninvasive indicators of biological maturation in adolescent male soccer players. *J. Sports Sci.* 30, 1705–1717. doi: 10.1080/02640414.2011.639382

Malina, R. M., Figueiredo, A. J., and Coelho-e-Silva, M. J. (2017). Body size of male youth soccer players: 1978–2015. *Sports Med.* 47, 1983–1992. doi: 10.1007/s40279-017-0743-x

Malina, R. M., Peña Reyes, M. E., Figueiredo, A. J., Coelho-e-Silva, M. J., Horta, L., Miller, R., et al. (2010). Skeletal age in youth soccer players: implication for age verification. *Clin. J. Sport Med.* 20, 469–474. doi: 10.1097/JSM.0b013e3181f827ea

Meylan, C., Cronin, J., Oliver, J., and Hughes, M. (2010). Talent identification in soccer: the role of maturity status on physical, physiological and technical characteristics. *Int. J. Sports Sci. Coach.* 5, 571–592. doi: 10.1260/1747-9541.5.4.571

Morrow, S. (2006). Scottish football: it's a funny old business. *J. Sports Econ.* 7, 90–95. doi: 10.1177/1527002505282867

Mujika, I., Vaeyens, R., Matthys, S. P. J., Santisteban, J., Goiriena, J., and Philippaerts, R. (2009). The relative age effect in a professional football club setting. *J. Sports Sci.* 27, 1153–1158. doi: 10.1080/02640410903220328

Padrón-Cabo, A., Rey, E., García-Soidán, J. L., and Penedo-Jamardo, E. (2016). Large scale analysis of relative age effect on professional soccer players in FIFA designated zones. *Int. J. Perform. Anal. Sport* 16, 332–346. doi: 10.1080/24748668.2016.11868890

Patel, R., Nevill, A., Cloak, R., Smith, T., and Wyon, M. (2019). Relative age, maturation, anthropometry and physical performance characteristics of players within an elite youth football academy. *Int. J. Sports Sci. Coach.* 14, 714–725. doi: 10.1177/1747954119879348

Reeves, M. J., Littlewood, M. A., McRobert, A. P., and Roberts, S. J. (2018a). The nature and function of talent identification in junior-elite football in English category one academies. *Soccer Soc.* 19, 1122–1134. doi: 10.1080/14660970.2018.1432385

Reeves, M. J., Roberts, S. J., McRobert, A. P., and Littlewood, M. A. (2018b). Factors affecting the identification of talented junior-elite footballers: a case study. *Soccer Soc.* 19, 1106–1121. doi: 10.1080/14660970.2018.1432383

SFA (2017). Scottish FA performance strategy. Available at: https://www.scottishfa.co.uk/performance/performance-strategy/ (Accessed September 22, 2020).

Skorski, S., Skorski, S., Faude, O., Hammes, D., and Meyer, T. (2016). The relative age effect in elite German youth soccer: implications for a successful career. *Int. J. Sports Physiol. Perform.* 11, 370–376. doi: 10.1123/ijspp.2015-0071

The English Premier League (2011). Elite player performance plan. Available at: https://www.premierleague.com/youth/EPPP/ (Accessed September 20, 2020).

Unnithan, V., White, J., Georgiou, A., Iga, J., and Drust, B. (2012). Talent identification in youth soccer. *J. Sports Sci.* 30, 1719–1726. doi: 10.1080/02640414.2012.731515

Vaeyens, R., Philippaerts, R. M., and Malina, R. M. (2005). The relative age effect in soccer: a match-related perspective. *J. Sports Sci.* 23, 747–756. doi: 10.1080/02640410400022052

Votteler, A., and Höner, O. (2014). The relative age effect in the German football TID programme: biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players. *Eur. J. Sport Sci.* 14, 433–442. doi: 10.1080/17461391.2013.837510

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2014). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

Yagüe, J. M., de la Rubia, A., Sánchez-Molina, J., Maroto-Izquierdo, S., and Molinero, O. (2018). The relative age effect in the 10 best leagues of male professional football of the union of european football associations (UEFA). *J. Sports Sci. Med.* 17, 409–416.

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Revisiting the Relative Age Effect From a Multidisciplinary Perspective in Youth Basketball: A Bayesian Analysis

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Relative age effect (RAE) is considered to bias the selection of young athletes and a cause of exclusion of many participants. The goal of the study was to unveil the effects of the birth quarter on physical performances and a set of psychological constructs in the age groups corresponding to the specialization years. A set of surveys with cross-sectional data collected from 2015 to 2019 in youth basketball was used. Three hundred and twenty-seven Brazilian players (127 females, 100 males), mean age 14.0 years, participated in the study. Counter-movement jump, line-drill, yoyo intermittent test, achievement goals, motivation for deliberate practice, and enjoyment were measured. Bayesian multilevel regression was performed. RAE was observed but its advantages did not persist and did not differentiate the players in the variables under scrutiny. The only predictor of athletic and psychological outcomes was chronological age. The initial advantage that triggered the coaches' decision to select individual players disappears during the specialization years. Coaches must overcome the superficial observation of young athletes based only on age groups and actual performances, avoiding hasty decisions that, unlike RAE, last in time and cannot be reversed.

Keywords: relative age effect, youth sport, selection, Bayesian analysis, multidiscipinary approach

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INTRODUCTION

The last decade witnessed a plethora of studies on talent identification and development, aiming at identifying accurate predictors of adult elite performance (for a review, Sarmento et al., 2018). The first common characteristic of these studies is their utilitarian ideology. Starting with measurements and assessments at different stages of childhood and adolescence, researchers try to discriminate the variables that can help coaches and managers to select or deselect athletes. The premise is that sport specialization is a necessary condition for performance and expertise development, the theoretical ground being the deliberate practice theory (Ericsson et al., 1993). The corollary is that specialization must start in childhood and deliver the best possible athlete at the end of the process, preferably under the guidance of qualified coaches.

The second common characteristic is the persistent inconsistency of methods, results, and interpretations of the results. As Zuber et al. (2016) put it, "it is simply not possible to consider the entire person-environment system empirically in holistic terms."

But if sports training is a behavioral praxis and is highly dependent on the multiplicity of contexts, the irruption of the biologic genotype occurs through the constructs of maturation and Relative Age Effect (RAE). The two phenomena are not to be confounded, but they are considered as an important source of biases in the decision-making process regarding selection or de-selection of young athletes, both male and female, and is transversal to multiple sports (Kirkendall, 2014; Hancock, 2017; Jones et al., 2018). However, unlike RAE, maturity status remains more difficult to assess in an exact manner (Koziel and Malina, 2018) as it requires a certain level of expertise in the field.

As the contemporary paradigm about sport specialization sets the beginning of training in a single sport at 5–6 years of age (Lovell et al., 2015; Müller et al., 2018), it means that the time for engagement, sampling, and performance covers childhood, adolescence, and the early stages of adulthood. According to Patel et al. (2019), it is precisely around 6 years that the RAE bias starts to occur. The phenomenon reflects a decision made by a coach at a certain stage of the participant's career. The negative effects of that decision would be the exclusion of potential talents just because they were chronologically younger by the time of selection.

Contrasting results about the eventual persistence of the bias in adult sport, depending on sport and contexts of competition have been noted (Werneck et al., 2016; Johnson et al., 2017; Haycraft et al., 2018; Rubajczyk and Rokita, 2018; Lupo et al., 2019; Kelly et al., 2020). However, the purpose of the present study is not to document the survival of the RAE during the path to expertise, but to investigate if the decision made by the coach when selecting athletes born in the first quarter of the year has effective consequences for the athletes' performance. Furthermore, the analysis was extended to all quarters of the year, encompassing all the possible effects originated by the date of birth.

Basketball performance is influenced by physical, physiological, and behavioral determinants (Carvalho et al., 2018). Particularly with young players, proper interpretations of body dimensions, functions, and behaviors need to adjust for the influence of growth and maturity status (Carvalho et al., 2018; Armstrong, 2019). Our goal here was to unveil the effects of the birth quarter on physical performances and a set of psychological constructs in the age groups corresponding to the specialization years. In previous studies we used an interdisciplinary perspective (Carvalho et al., 2018; Soares et al., 2020), combining measures of physical performance with psychological assessment through the use of questionnaires. Hence, the dependent variables are related to speed, strength, and intermittent endurance (Stojanovic et al., 2018), but also to achievement goals (Helmreich et al., 1978), motivation for deliberate practice (de Bruin et al., 2007) and enjoyment (Wiersma, 2001). It seems plausible that the physical and psychological advantages seen by the coach at the time of selection are translated into better athletic performances and psychosocial adaptations.

We choose the Brazilian context because traditionally participation in organized youth sport is possible only through a process of tryouts performed at the beginning of the season when coaches decide those who are accepted in the team and those who are excluded. The ages under observation (10–18 years) correspond to the sampling and specialization stages defined in the current development models (Côté and Vierimaa, 2014).

In sports sciences, samples are often non-normal and imbalanced, and the sources of variation are multiple and nested in hierarchical orders of influence. On the other hand, the combination of physiological and behavioral measures can be potentially noisy and lead to biased and unreliable inferences. The present analytical approach is deemed to deal with imbalanced samples and missing values in some outcomes. As an alternative to the exclusion of athletes, we modeled our data using a Bayesian multilevel modeling framework.

The purposes of the present study are: to estimate the effects of the birth quarter, combined with gender, age group, maturity status, and age of start of organized training on (a) the performance in counter-movement jump, line drill, and yoyo, and (b) on measures of achievement goals, motivation to deliberate practice and enjoyment among basketball players aged 10–18 years.

METHODS

Data

The data in this study was assembled by combining surveys with cross-sectional data collected from 2015 to 2019 in youth basketball. We considered observations from youth female and male teams in the São Paulo, Santa Catarina, and Rio Grande do Sul basketball federations: These federations are affiliated in the Confederação Brasileira de Basketball (Brazilian Basketball Confederation). The sample considered 327 Brazilian adolescent basketball players aged 14.0 (1.7) years, on average, with a range between 9.5 and 17.9 years. The sample included 127 female and 200 male players. The players participated in regular training sessions (3–5 sessions; 270–450 min per week) in their clubs. The competitive seasons typically run between February/March until November/December, including about 20–30 games per season. We grouped players as under-11, under-13, under-15, and under-17, assuming a 2-year range, which is the most common competitive age group in Brazilian youth sports.

Ethical approval was obtained from the authors' institutional ethics committee. All participants were informed about the nature of the survey, that participation was voluntary, and that they could withdraw from the study at any time. All participants and their parents or legal guardians provided written informed consent.

Procedures

Chronological age was calculated by subtracting birth date from the day of testing to the nearest 0.1 year. Stature was measured with a portable stadiometer (Seca model 206, Hanover, MD, USA) to the nearest 0.1 cm. Body mass was measured with a calibrated portable balance (Seca model 770, Hanover, MD, USA) to the nearest 0.1 kg. Reliability estimates for the observer are published elsewhere (Soares et al., 2020). Considering the month of birth, we grouped players as follows: 1st quarter ($n = 111$), when a player was born in January, February, or March; 2nd quarter ($n = 90$), when a player was born in April, May, or June;

3rd quarter ($n = 61$), when a player was born in July, August, or September; 4th quarter ($n = 65$), when a player was born in October, November, or December.

The assessment of biological maturation is often overlooked. In this study maturity status was estimated based on the gender-specific maturity offset protocol (Moore et al., 2015). The offset equations predict time before or after PHV based on chronological age and stature. Then it is possible to estimate each player's age at PHV. Hence, the offset equations attempt to provide an estimation of timing (i.e., the age at which a given pubertal milestone is reached). Often the interest and interpretations lie on information about tempo, i.e., the rate of within-person progression through maturation stages. Hence, we compared the estimates of timing obtained with the offset equations against the population references based on meta-analysis estimations, providing an interpretation of between-individuals variation in maturity status. In particular, we contrasted the players' estimated age at PHV against a gender-specific reference age at PHV derived from a meta-analysis of longitudinal growth studies (Malina et al., 1988). The reference age at PHV was 11.9 (90% credible interval: 11.8, 12.0) years and 13.9 (90% credible interval; 13.8, 14.0) years for girls and boys, respectively (Lima et al., 2020). Then we classified players as follows: early maturers ($n = 139$), when estimated age at PHV was lower than the gender-specific reference age at PHV by more than 6 months; average matures ($n = 162$) when players' estimated age at PHV was within plus/minus 6 months of the gender-specific age at PHV; late matures ($n = 26$), when estimated age at PHV was higher than the gender-specific reference age at PHV by more than 6 months. Nevertheless, we assume the limitations of the maturity offset protocol (Carvalho et al., 2018), particularly at the extremes of the observed age range where bias may be more significant (Koziel and Malina, 2018).

The onset in basketball was considered as the self-reported age when athletes started formal training and competition in basketball, under the supervision of a coach within a youth basketball program registered in the state basketball federation, and with no participation in practice and competition in other organized sport. Then the onset of deliberate basketball practice was related to two biological maturation milestones, the age of onset of the pubertal growth spurt and the age at PHV. Again, the biological milestones were estimated based on data from longitudinal growth studies (Malina et al., 1988). Details about the Bayesian multilevel modeling to perform a meta-analysis and derive the estimates are provided elsewhere. The reference age of the pubertal growth spurt onset was 9.4 (90% credible interval: 9.0, 9.8) years and 11.1 (90% credible interval: 10.8, 11.5) years for girls and boys, respectively. We grouped the players by the onset of deliberate basketball practice as follows: pre-puberty deliberate basketball practice onset ($n = 155$), the players who started practice before the reference age of pubertal growth spurt onset; mid-puberty deliberate basketball practice onset ($n = 135$), the players starting practice between the reference ages of pubertal growth spurt onset age and at PHV; late-puberty deliberate basketball practice onset ($n = 37$), the players starting practice after the reference age at PHV.

To describe players functional capacities we used the vertical jump with countermovement (Bosco et al., 1983), a short-term maximal running protocol, the line drill test (Semenick, 1990; Carvalho et al., 2017) and intermittent endurance test, the yo-yo intermittent recovery level 1 test (yo-yo IR1) (Bangsbo, 1994). Details about the functional performance procedures and reliability estimates are available elsewhere (Carvalho et al., 2018, 2019; Soares et al., 2020).

The psychological factors were assessed using the deliberate practice motivation questionnaire (de Bruin et al., 2008), the work and family orientation questionnaire (Helmreich et al., 1978), and the sources of enjoyment in youth sport questionnaire (Wiersma, 2001). It is composed by 28 items responded in a five-point Likert scale (1 = not at all, 2 = a little, 3 = not sure, 4 = yes, and 5 = very much), assessing, in the Portuguese version, the *s* (four items). We used an adapted version for basketball, translated and validated to Portuguese (Gonçalves et al., 2011) of the deliberate practice motivation questionnaire, originally designed for chess (de Bruin et al., 2007, 2008). The reliability of the adapted Portuguese version has been reported with data in youth basketball from the same age range of the present study elsewhere (Gonçalves et al., 2011). Similar to our previous observations in youth basketball (Gonçalves et al., 2011; Carvalho et al., 2018; Soares et al., 2020), we used the last three subscales of achievement from the work and family orientation questionnaire (Helmreich et al., 1978). Subscales considered were work (the desire to face challenging tasks the desire to practice and perform well), mastery (the desire to face challenging tasks), and competitiveness (the desire to be better when compared to others). For enjoyment we used the Portuguese version translated and validated by Santos and Gonçalves (2012), considering five subscales: positive parental involvement, self-referenced competencies, other-referenced competencies and recognition, effort expenditure and affiliation with peers.

Statistical Analysis

Modeling Approach

Often, sports science survey samples are non-representative and imbalanced, there are hierarchical sources of variation or cross-classified nesting, and physiological and behavioral measures can be noisy measures that can potentially lead to biased and unreliable inferences. The present data is imbalanced and there are missing values in some outcomes. As an alternative to excluding players, we modeled our data using Bayesian multilevel regression and poststratification (Gelman and Little, 1997). The technique allows us to estimate the outcomes in small groups using varying effects for individual-level predictors such as gender, age group, maturity status, or onset of deliberate practice, that take on multiple levels in the data (Kennedy and Gelman, 2020) In the second part of the method, we use the multilevel model estimates to predict the players' outcomes for groups defined in a post-stratification dataset (i.e., gender, birth quarter, age group, maturity status, and the onset of deliberate basketball practice). The post-stratification table has an observation corresponding to each group defined for all combinations of the variables included in the model. Since, in the present study, models included two gender levels, four birth quarter levels, four age-group levels, three maturity status levels, and three onsets of deliberate practice levels, the post-stratification table encompassed 288 rows (2 × 4 × 4 × 3 × 3), including the sample size, in each group. After predicting the outcome variable for each group, we aggregated estimates for gender (or other subgroup units) with the subgroup sample sizes. Hence, the method allows us to take full use of all available data. Lastly, we prefer Bayesian methods as it provides a natural approach to account for different sources of inferential uncertainty (Kennedy and Gelman, 2020).

Model Specification, Priors, and Computation

Initially, we standardized the outcomes for interpretative convenience and computational efficiency. Our initial multilevel models were fitted with the intend to reproduce the naïve perceptions of the coach when selecting the players for the team. This reflects the common contexts in youth sport, where most clubs rely on the coaches' "eye," with little help of specialized scouts or a multidisciplinary staff. Hence, the individual player's outcome was estimated as a function of his/her gender, birth quarter, and age group (for player i, with indexes g, b, and a for gender, birth quarter, and age group). Also, we allowed players in each birth quarter to vary when grouped by age group:

$$y_i = \beta^0 + \alpha^{gender}_{g[i]} + \alpha^{birth\ quarter}_{b[i]} + \alpha^{age\ group}_{a[i]} + \alpha^{age\ group.birth\ quarter}_{a[i],b[i]} \quad (1)$$

The terms after the intercept are modeled as group effects (also referred to as random effects) drawn from normal distributions with variances to be estimated from the data:

$\alpha^{gender}_{g[i]} \sim N(0, \sigma^2_{gender})$, for g = 1, 2.
$\alpha^{birth\ quarter}_{b[i]} \sim N(0, \sigma^2_{birth\ quarter})$, for b = 1, 2, 3, and 4.
$\alpha^{age\ group}_{a[i]} \sim N(0, \sigma^2_{age\ group})$, for a = 1, 2, 3, and 4.
$\alpha^{age\ group.birth\ quarter}_{a[i],b[i]} \sim N(0, \sigma^2_{age\ group,birth\ quarter})$, for a = 1, 2, 3, and 4, and b = 1, 2, 3, and 4.

We extended the initial multilevel models to adjust for potential influences of maturity status and the onset of deliberate basketball practice. Hence, the individual player's outcome was estimated as a function of his/her characteristics, i.e., gender, birth quarter, age group, maturity status, and the onset of deliberate basketball practice (for player i, with indexes g, b, a, m, and d for gender, birth quarter, age group, maturity status, and deliberate basketball practice, respectively). Again, we allowed players in each birth quarter to vary when grouped by age group:

$$y_i = \beta^0 + \alpha^{gender}_{g[i]} + \alpha^{birth\ quarter}_{b[i]} + \alpha^{age\ group}_{a[i]} + \alpha^{maturity\ status}_{m[i]} + \alpha^{deliberate\ practice}_{d[i]} + \alpha^{age\ group.birth\ quarter}_{a[i],b[i]} \quad (2)$$

Again, the terms after the intercept are modeled as group effects drawn from normal distributions with variances to be estimated from the data:

$\alpha^{gender}_{g[i]} \sim N(0, \sigma^2_{gender})$, for g = 1, 2.
$\alpha^{birth\ quarter}_{b[i]} \sim N(0, \sigma^2_{birth\ quarter})$, for b = 1, 2, 3, and 4.
$\alpha^{age\ group}_{a[i]} \sim N(0, \sigma^2_{age\ group})$, for a = 1, 2, 3, and 4.
$\alpha^{maturity\ status}_{m[i]} \sim N(0, \sigma^2_{maturity\ status})$, for m = 1, 2, 3.
$\alpha^{deliberate\ practice}_{d[i]} \sim N(0, \sigma^2_{deliberate\ practice})$, for d = 1, 2, 3.
$\alpha^{age\ group.birth\ quarter}_{a[i],b[i]} \sim N(0, \sigma^2_{age\ group,birth\ quarter})$, for a = 1, 2, 3 and 4, and b = 1, 2, 3, and 4.

For computational and interpretation convenience, we standardized (*z*-score) the outcomes. We used weakly informative priors to regularize our estimates, normal priors (0, 2) for the population-level parameter (i.e., intercept), and normal priors (0, 1) for the group-level parameters. By standardizing the outcomes and using a normal (0, 1) prior for the parameters, we consider being unlikely for the effects among group-level estimates to be greater than one standard deviation of the outcome. We run four chains for 2,000 iterations with a warm-up length of 1,000 iterations for each model. We inspect the convergence of the chains with trace plots and inspected and validated the models using posterior predictive checks (Gelman et al., 2013). The models were implemented using Stan which was called using the "brms" package (Bürkner, 2017), in R statistical language (R Core Team, 2018). All data and R codes are available online at https://osf.io/9rbm5.

TABLE 1 | Descriptive statistics [mean (standard deviation)] for the total sample of young female and male basketball players.

	Mean (standard deviation)
Chronological age, yrs	14.0 (1.7)
Maturity offset, yrs	1.25 (1.69)
Estimated age at peak height velocity, yrs	12.7 (0.8)
Onset of basketball deliberate practice, yrs	10.4 (2.3)
Stature, cm	169.0 (12.1)
Body mass, kg	63.8 (15.3)
Countermovement jump, cm	29.2 (6.3)
Line drill test, s	34.58 (2.83)
Yo-yo intermittent recovery test level-1, m	721.6 (417.8)
Performance score, *z*-score	0.11 (2.55)
Will to excel, 1–5	4.15 (0.77)
Will to compete, 1–5	4.40 (0.56)
Mastery, 1–5	4.20 (0.60)
Work, 1–5	4.48 (0.48)
Competitiveness, 1–5	3.77 0.71)
Self-referenced competencies, 1–5	4.50 (0.52)
Others-referenced competencies, 1–5	3.81 (0.81)
Effort expenditure, 1–5	4.73 (0.47)
Positive parental involvement, 1–5	4.42 (0.70)
Affiliation with peers, 1–5	4.51 (0.62)

RESULTS

Descriptive statistics for the total sample are summarized in **Table 1**. Note that standardization was based on the mean and standard deviation for the total sample.

The analysis of the sample distribution shows that those born in the first quarter of the year represent 33% of the total. If we add those born in the second quarter, we account for 61% of the total sample. So, the selection bias is real. On the other hand, late maturers represent only 8% of the total of the sample, with average maturers accounting for almost half of the athletes (**Tables 2**, **3**).

The results from the multilevel models considering the influence of gender, birth quarter, age group, maturity status, and the onset of deliberate basketball practice on the outcomes are summarized in **Table 4**. Given the extension of the results the plots of outcomes adjusted by birth quarter, separately gender and contrasting by age group, maturity status, or onset of deliberate basketball practice are available as supplementary material (https://osf.io/9rbm5). Here we present the plot of performance score, as an overall descriptor of players' athletic performance, examining the relative age effect separately by gender, and grouping by age group and onset of deliberate basketball practice in **Figure 1**. The adjusted estimates for athletic performance showed a similar pattern of RAE for both female and male athletes. Overall, there was a small, at best, trend of variation by birth quarter, as players born in the 1st and 4th trimesters showed better performance scores, particularly for the under 17 age group and for players with a late onset of deliberate basketball practice. Adjusted estimates showed that older players had a better athletic performance. Players with a late onset of deliberate basketball practice appeared to present slightly better athletic performance scores, however, uncertainty estimates were large.

Regarding the orientation to deliberate practice, there was a trend of lower values of will to compete for players born in the 3rd and 4th trimesters in the under 15 and 17 age groups (**Figure 2**). As for achievement goals, mastery, work, and competitiveness, there was a trend of higher values of work dimension for the under 13 age group players born in the 3rd and 4th trimesters, independent of gender (**Figure 3**).

Regarding the sources of enjoyment, multilevel modeling and post-stratified estimates showed a substantial variation by birth trimester across age groups, particularly on the scores of others-referenced competencies of under 17 players (**Figure 4**). For self-referenced competencies, the under-15 players born in the 1st trimester showed higher scores. It is important to stress that there was no variation by gender on sources of enjoyment outcomes. For affiliation with peers, under-13 players born in the 4th trimester showed the higher scores, and under-15 players born in the 3rd quarter showed present the lowest scores. For effort expenditure, under-15 players showed contrasting scores between those born in the 1st and 2nd trimesters and those born in the 3rd and 4th trimesters; but the under-11 players showed consistently lower scores.

TABLE 2 | Distribution by month quarter across the age group sample of young female and male basketball players.

	Under 11		Under 13		Under 15		Under 17		Total
	Female	Male	Female	Male	Female	Male	Female	Male	
1st quarter	4	6	16	27	17	29	6	6	111
2nd quarter	3	3	16	25	9	20	4	10	90
3rd quarter	5	7	8	16	5	11	6	3	61
4th quarter	4	7	7	13	13	13	4	4	65
Total	16	23	47	81	44	73	20	23	327

TABLE 3 | Distribution by month quarter across the estimated biological maturity status in the sample of young female and male basketball players.

	Early maturers		Average maturers		Late maturers		Total
	Female	Male	Female	Male	Female	Male	
1st quarter	3	41	33	27	7	0	111
2nd quarter	4	37	25	21	3	0	90
3rd quarter	1	20	19	15	4	2	61
4th quarter	5	28	14	8	9	1	65
Total	13	126	91	71	23	3	327

TABLE 4 | Multilevel regression models posterior estimations and 90% credible intervals of young basketball players by gender, age group, maturity status, onset of deliberate practice, birth quarter, and by the interaction of age group and birth quarter.

	Population-level effects	Group-level effects					
	Intercept	**Gender**	**Age group**	**Maturity status**	**Onset of deliberate practice**	**Birth quarter**	**Age group, birth quarter**
Countermovement jump	−0.13 (−1.05; 0.82)	**0.92 (0.43; 1.56)**	**0.72 (0.38; 1.18)**	0.28 (0.04; 0.61)	0.16 (0.01; 0.39)	0.12 (0.02; 0.27)	0.08 (0.01; 0.18)
Line drill test	0.13 (−0.73; 1.01)	**0.67 (0.22; 1.31)**	**0.96 (0.57; 1.44)**	0.18 (0.02; 0.45)	0.17 (0.02; 0.37)	0.12 (0.02; 0.27)	0.12 (0.02; 0.23)
Yo-yo intermittent recovery test level-1	−0.02 (−1.04; 0.95)	**0.82 (0.36; 1.42)**	**0.69 (0.35; 1.13)**	0.26 (0.04; 0.56)	**0.47 (0.17; 0.89)**	0.24 (0.04; 0.50)	**0.21 (0.05; 0.37)**
Performance score	−0.13 (−1.57; 1.29)	**1.34 (0.78; 2.01)**	**1.66 (1.13; 2.25)**	0.43 (0.06; 0.78)	0.38 (0.05; 0.81)	0.26 (0.03;0.57)	**0.41 (0.10; 0.72)**
Will to excel	−0.05 (−0.72; 0.62)	**0.60 (0.16; 1.22)**	0.16 (0.02; 0.34)	0.23 (0.03; 0.52)	0.28 (0.05; 0.63)	0.23 (0.04; 0.48)	0.09 (0.01; 0.20)
Will to compete	0.04 (−0.55; 0.65)	0.37 (0.03; 0.94)	0.28 (0.07; 0.57)	0.35 (0.08; 0.74)	0.25 (0.03; 0.58)	0.18 (0.02; 0.38)	**0.22 (0.09; 0.36)**
Mastery	0.01 (−0.65; 0.63)	0.57 (0.14; 1.17)	0.17 (0.02; 0.38)	0.27 (0.03; 0.60)	0.19 (0.02; 0.45)	0.17 (0.02; 0.45)	0.13 (0.02; 0.25)
Work	−0.03 (−0.68; 0.62)	0.53 (0.12; 1.15)	0.23 (0.04; 0.47)	0.25 (0.03; 0.62)	0.29 (0.06; 0.63)	0.23 (0.04; 0.50)	**0.23 (0.09; 0.38)**
Competitiveness	0.02 (−0.64; 0.70)	0.55 (0.13; 1.16)	0.26 (0.04; 0.55)	0.28 (0.03; 0.63)	0.33 (0.06; 0.71)	0.14 (0.02; 0.33)	0.13 (0.02; 0.27)
Self-referenced competencies	0.04 (−0.56; 0.63)	0.43 (0.06; 1.00)	0.15 (0.02; 0.33)	0.30 (0.05; 0.64)	0.31 (0.05; 0.67)	0.13 (0.02; 0.28)	0.14 (0.03; 0.26)
Others-referenced competencies	−0.08 (−0.76; 0.55)	0.37 (0.03; 0.95)	**0.39 (0.10; 0.78)**	0.28 (0.04; 0.62)	**0.44 (0.12; 0.88)**	0.17 (0.02; 0.39)	**0.20 (0.05; 0.34)**
Effort expenditure	−0.03 (−0.59; 0.56)	0.23 (0.03; 0.52)	0.40 (0.04; 1.00)	0.22 (0.02; 0.53)	0.25 (0.03; 0.60)	0.18 (0.02; 0.40)	**0.32 (0.18; 0.48)**
Positive parental involvement	−0.01 (−0.74; 0.65)	0.57 (0.14; 1.15)	0.32 (0.10; 0.61)	0.21 (0.02; 0.52)	0.39 (0.07; 0.82)	0.17 (0.02; 0.38)	0.16 (0.02; 0.30)
Affiliation with peers	−0.04 (−0.59; 0.50)	0.16 (0.02; 0.35)	0.39 (0.05; 0.93)	0.21 (0.02; 0.49)	0.34 (0.05; 0.75)	0.14 (0.02; 0.32)	**0.20 (0.05; 0.35)**

Estimates in bold indicate substantial a variation at group-level on the outcome.

DISCUSSION

The purpose of the study was to estimate the effects of the birth quarter on a set of athletic and psychosocial variables, assembled through surveys with cross-sectional data, covering 5 years. The distribution of the sample shows an overrepresentation of players born in the first quarter of the year and of early- and average maturers. The utility of Bayesian methods and multilevel techniques with poststratification is evident, allowing us to overcome the distribution pitfalls and to estimate the outcomes in such small groups. To our knowledge, it is one of the few studies to perform this research design with the aforementioned statistical analysis (Kalén et al., 2020).

Our initial model is simpler and looks to reproduce the naïve perceptions of the coach when selecting the players for the team. In youth sport, most clubs rely on the coaches' "eye," with little help from specialized scouts or a multidisciplinary staff. Thus, the coach makes a decision based on what he/she sees at the moment, e.g., the more capable athletes in the given situation, in that particular age group. Within the present sample, the RAE selection bias followed the trends reported in the literature (Arrieta et al., 2016; Hancock, 2017; Haycraft et al., 2018). Furthermore, the bias seems to be complemented by the overrepresentation of early- and average maturers, suggesting a homology between the RAE and the maturity status. But a close inspection of **Table 2** reveals that the players born in the 4th quarter are early-maturers. The result is especially evident for male players, as the girls born in the 1st quarter and early-maturers are fewer than their male peers.

This reflects further evidence that RAE and maturity status are not to be confounded, although the present study suggests the phenomenological emergence of the "survival of the fittest" (Jones et al., 2018), as, at least for boys, those retained by the coaches are the older ones, chronologically and biologically. Hence, we added complexity to the second model by introducing maturity status and the onset of organized basketball practice as explanatory variables. The results do not seem to follow an established pattern, in line with the birth quarter or age group,

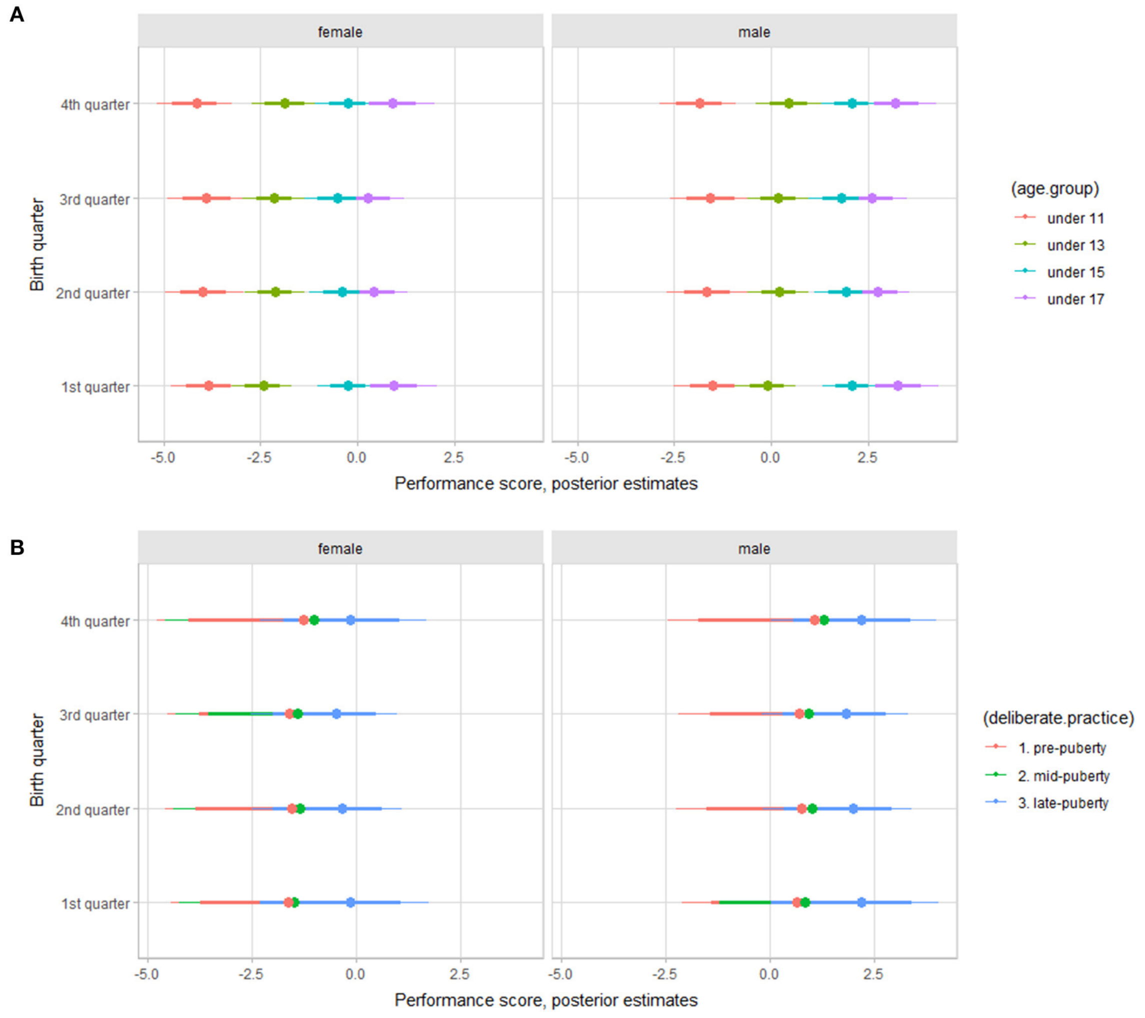

FIGURE 1 | Posterior estimations for Performance score (*z*-score scale) by age group **(A)**, onset of deliberate basketball practice **(B)** in young female and male basketball players (67 and 90% credible intervals).

but they express a common characteristic: being born in the 1st quarter does not necessarily present any advantage in all variables under scrutiny. Considering for athletic performance, achievement goals, or other-referenced competencies, the best scores are estimated to under-17 players, regardless of birth quarter and maturation, meaning that chronological age explains the results.

In most of the variables, the results by birth quarter and age group are difficult to interpret and probably reflect the specificities of the diverse contexts. The effects of biological maturation and accumulated experience in organized basketball did not account substantially for the interpretation of the outcomes. This may be partially explained by the trend of homogeneity in size, function, and experience among young athletes as results of the selection process in youth sports (Malina, 1994). It seems that the superficial look of the coach through the lens of the age group has no consequences in the long term. The lack of explanatory power of the variables included in the model corroborates the argument that during the sampling and specialization years (Côté and Vierimaa, 2014) the outcomes are more a consequence of the athletes' responses to the training loads and to the ecologies of practice than determined by a particular characteristic like the birth quarter, maturity status, or the year of engagement in basketball.

The assessment of athletic and psychosocial variables is important because sports training is a holistic intervention that cannot be separated through isolated and analytical approaches (Carvalho et al., 2018). Furthermore, there are studies (McCarthy et al., 2016; Cumming et al., 2018) pointing that younger athletes, later maturers, or born in the 4th quarter of the year, seem to display a psychological advantage. The present study shows that there are no differences in psychosocial constructs and,

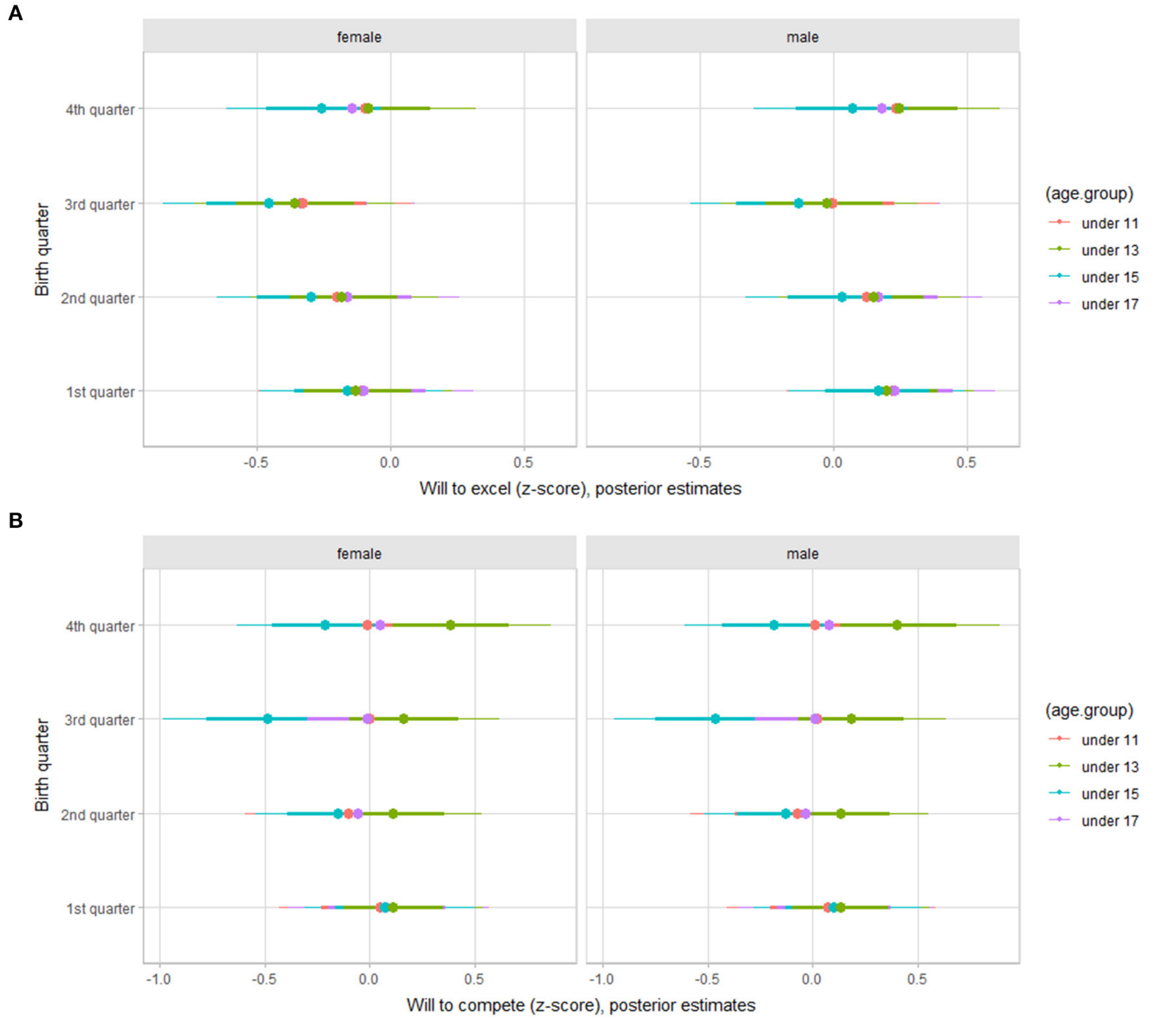

FIGURE 2 | Posterior estimations for standardized scores for will to excel **(A)** and will to compete **(B)** by age group in young female and male basketball players (67 and 90% credible intervals).

when they appear, are generally in favor of the chronologically older players.

There are conflicting reports about the persistence or reversal of RAE advantage in adult teams (McCarthy et al., 2016; Rubajczyk and Rokita, 2018; Lupo et al., 2019). The concern with RAE is linked to the fact that relatively young players are less likely to be selected into the organized sport system, but those who survive are more likely to transition to elite competitive levels.

But our study brings evidence that the initial advantage that triggered the decision to select individual players disappear much sooner, albeit when is too late for the coach to reverse the exclusion decision. The risk is to look for an archetype athlete with a theoretical existence belonging to all theories, as the product of an explanatory classification, one which is altogether similar to those of zoologists and botanists. These classifications give the illusion that scientists and coaches can explain and predict the future outcomes of the classified individuals, including their propensity to attain elite performances. But the reality is more prosaic and superficial cross-sectional evaluations do not translate often into vivid existences.

One final remark must be made about the gender issue. In the study, there are no apparent differences between boys and girls regarding the variables under-appreciation, and they seem to present the same pattern of results, in both athletic and psychosocial measures. This does not mean that there are no differences at all and that they must be coached in the same way.

The study has some limitations. It is confined to one sport and, although representing the local contexts of practice, it stills lacks critical dimension, namely regarding the balance between male and female athletes. We opted for a non-longitudinal design as the combination of surveys with cross-sectional data allowed us to model the data and estimate the players' outcomes for groups

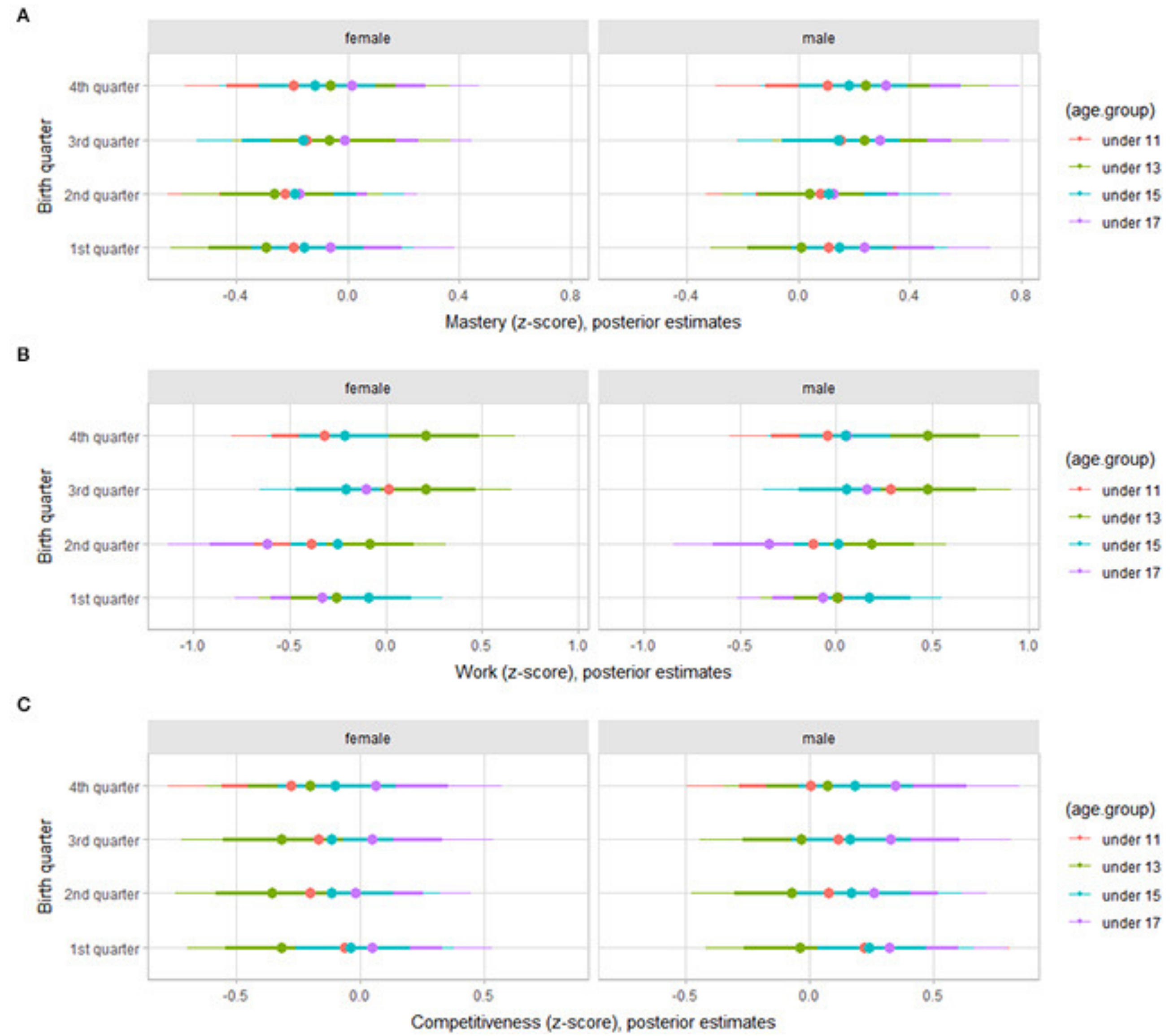

FIGURE 3 | Posterior estimations for standardized scores for mastery **(A)**, work **(B)**, and competitiveness **(C)** by age group in young female and male basketball players (67 and 90% credible intervals).

defined in a post-stratification dataset. But a longitudinal design would be also a suitable method to reach the same purposes. The study of multiple sports with larger samples, alongside the clear demarcation between RAE and maturity status, are future avenues for research.

CONCLUSIONS

RAE has been consistently present in recent literature as selection bias and a factor of exclusion of participants and potential talents. Most studies have assessed the persistence or reversal of RAE among adult athletes. The present study shows that the initial advantage/disadvantage that was the cause of the decision to select or exclude disappears sooner than expected, as the athletes grow older and become fully immersed in the sport. Coaches must overcome the superficial observation of young athletes based only on age groups and actual performances and endorse a pragmatic realism, avoiding hasty decisions that, unlike RAE, last in time and cannot be reversed.

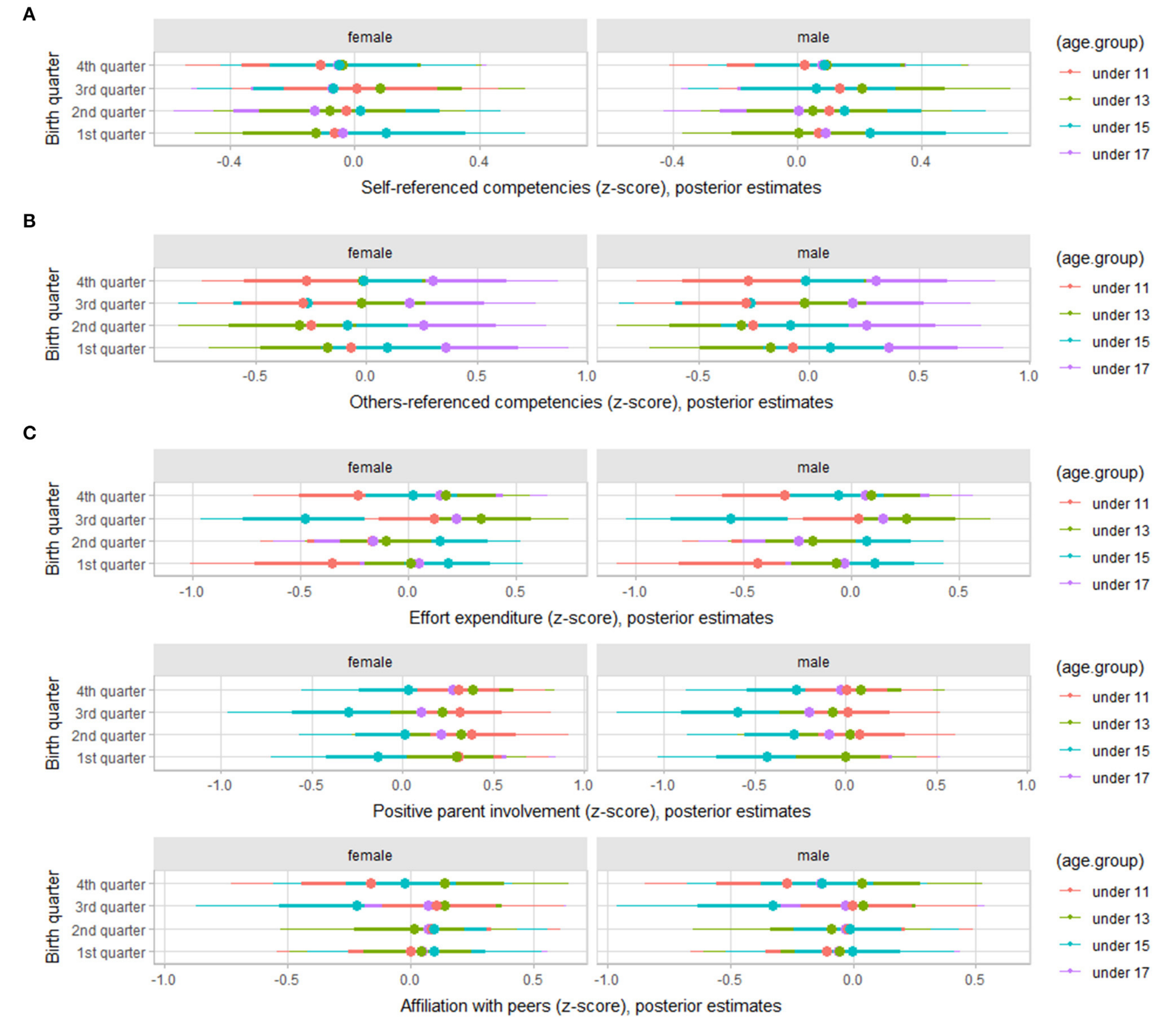

FIGURE 4 | Posterior estimations for standardized scores for self-referenced competencies **(A)**, others-referenced competencies **(B)**, effort expenditure **(C)**, positive parental involvement **(D)**, and affiliation with peers **(E)** by age group in young female and male basketball players (67 and 90% credible intervals).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are publicly available. This data can be found at: [https://osf.io/9rbm5].

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of the Federal University of Santa Catarina. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the design, data collection, and writing of the paper.

REFERENCES

Armstrong, N. (2019). *Development of the Youth Athlete*. Abingdon: Routledge.

Arrieta, H., Torres-Unda, J., Gil, S. M., and Irazusta, J. (2016). Relative age effect and performance in the U16, U18 and U20 European basketball championships. *J. Sports Sci.* 34, 1530–1534. doi: 10.1080/02640414.2015.1122204

Bangsbo, J. (1994). *Fitness Training in Footbal - A Scientific Approach*. Bangsvaerd: HO Storm.

Bosco, C., Luhtanen, P., and Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *Eur. J. Appl. Physiol. Occup. Physiol.* 50, 273–282. doi: 10.1007/BF00422166

Bürkner, P.-C. (2017). brms: an R package for bayesian multilevel models using stan. *J. Stat. Softw.* 80, 1–28. doi: 10.18637/jss.v080.i01

Côté, J., and Vierimaa, M. (2014). The developmental model of sport participation: 15 years after its first conceptualization. *Sci. Sports* 29, S63–S69. doi: 10.1016/j.scispo.2014.08.133

Carvalho, H. M., Gonçalves, C. E., Collins, D., and Paes, R. R. (2018). Growth, functional capacities and motivation for achievement and competitiveness in youth basketball: an interdisciplinary approach. *J. Sports Sci.* 36, 742–748. doi: 10.1080/02640414.2017.1340654

Carvalho, H. M., Gonçalves, C. E., Grosgeorge, B., and Paes, R. R. (2017). Validity and usefulness of the line drill test for adolescent basketball players: a Bayesian multilevel analysis. *Res. Sports Med.* 25, 333–344. doi: 10.1080/15438627.2017.1314296

Carvalho, H. M., Leonardi, T. J., Soares, A. L. A., Paes, R. R., Foster, C., and Gonçalves, C. E. (2019). Longitudinal changes of functional capacities among adolescent female basketball players. *Front. Physiol.* 10:339. doi: 10.3389/fphys.2019.00339

Cumming, S. P., Searle, C., Hemsley, J. K., Haswell, F., Edwards, H., Scott, S., et al. (2018). Biological maturation, relative age and self-regulation in male professional academy soccer players: A test of the underdog hypothesis. *Psychol. Sport Exerc.* 39, 147–153. doi: 10.1016/j.psychsport.2018.08.007

de Bruin, A. B., Rikers, R. M., and Schmidt, H. G. (2007). The influence of achievement motivation and chess-specific motivation on deliberate practice. *J. Sport Exerc. Psychol.* 29, 561–583. doi: 10.1123/jsep.29.5.561

de Bruin, A. B., Smits, N., Rikers, R. M., and Schmidt, H. G. (2008). Deliberate practice predicts performance over time in adolescent chess players and drop-outs: a linear mixed models analysis. *Br. J. Psychol.* 99(Pt 4), 473–497. doi: 10.1348/000712608X295631

Ericsson, K. A., Krampe, R. T., and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychol. Rev.* 100, 363–406. doi: 10.1037/0033-295X.100.3.363

Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., and Rubin, D. B. (2013). *Bayesian Data Analysis, 3rd Edn*. Boca Raton, FL: Chapman & Hall/CRC Press.

Gelman, A., and Little, T. C. (1997). Poststratification into many categories using hierarchical logistic regression. *Surv. Methodol.* 23, 127–135.

Gonçalves, C. E., Silva, M., Carvalho, H. M., and Gonçalves, A. (2011). Why do they engage in such hard programs? The search for excellence in youth basketball. *J. Sports Sci. Med.* 10, 458–464.

Hancock, D. J. (2017). Female relative age effects and the second-quartile phenomenon in young female ice hockey players. *Psychol. Sport Exerc.* 32, 12–16. doi: 10.1016/j.psychsport.2017.05.002

Haycraft, J. A. Z., Kovalchik, S., Pyne, D. B., Larkin, P., and Robertson, S. (2018). The influence of age-policy changes on the relative age effect across the Australian Rules football talent pathway. *J. Sci. Med. Sport* 21, 1106–1111. doi: 10.1016/j.jsams.2018.03.008

Helmreich, R. L., Beane, W., Lucker, G. W., and Spence, J. T. (1978). Achievement motivation and scientific attainment. *Personal. Soc. Psychol. Bull.* 4, 222–226. doi: 10.1177/014616727800400209

Johnson, A., Farooq, A., and Whiteley, R. (2017). Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci. Med. Football* 1, 157–163. doi: 10.1080/24733938.2017.1283434

Jones, B. D., Lawrence, G. P., and Hardy, L. (2018). New evidence of relative age effects in "super-elite" sportsmen: a case for the survival and evolution of the fittest. *J. Sports Sci.* 36, 697–703. doi: 10.1080/02640414.2017.1332420

Kalén, A., Lundkvist, E., Ivarsson, A., Rey, E., and Pérez-Ferreirós, A. (2020). The influence of initial selection age, relative age effect and country long-term performance on the re-selection process in European basketball youth national teams. *J. Sports Sci.* 1–7. doi: 10.1080/02640414.2020.1823109. [Epub ahead of print].

Kelly, A. L., Jackson, D. T., Taylor, J. J., Jeffreys, M. A., and Turnnidge, J. (2020). "Birthday-Banding" as a strategy to moderate the relative age effect: a case study into the england squash talent pathway. *Front. Sports Act Living* 2:573890. doi: 10.3389/fspor.2020.573890

Kennedy, L., and Gelman, A. (2020). Know your population and know your model: using model-based regression and poststratification to generalize findings beyond the observed sample. *ArXiv* e-prints 1906.11323(1906.11323 [stat.AP]).

Kirkendall, D. T. (2014). The relative age effect has no influence on match outcome in youth soccer. *J. Sport Health Sci.* 3, 273–278. doi: 10.1016/j.jshs.2014.07.001

Koziel, S. M., and Malina, R. M. (2018). Modified maturity offset prediction equations: validation in independent longitudinal samples of boys and girls. *Sports Med.* 48, 221–236. doi: 10.1007/s40279-017-0750-y

Lima, A. B., Nascimento, J. V., Leonardi, T. J., Soares, A. L., Paes, R. R., Gonçalves, C. E., et al. (2020). Deliberate practice, functional performance and psychological characteristics in young basketball players: a bayesian multilevel analysis. *Int. J. Environ. Res. Public Health* 17:4078. doi: 10.3390/ijerph17114078

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in english Lower-League development programmes: the relationships between Relative Age, Maturation, Anthropometry, and Physical Fitness. *PLOS ONE* 10:e0137238. doi: 10.1371/journal.pone.0137238

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2019.01465

Malina, R. M. (1994). Physical growth and biological maturation of young athletes. *Exerc. Sport Sci. Rev.* 22, 389–433. doi: 10.1249/00003677-199401000-00012

Malina, R. M., Bouchard, C., and Beunen, G. (1988). Human growth: selected aspects of current research on well-nourished children. *Annu. Rev. Anthropol.* 17, 187–219. doi: 10.1146/annurev.an.17.100188.001155

McCarthy, N., Collins, D., and Court, D. (2016). Start hard, finish better: further evidence for the reversal of the RAE advantage. *J. Sports Sci.* 34, 1461–1465. doi: 10.1080/02640414.2015.1119297

Moore, S. A., McKay, H. A., Macdonald, H., Nettlefold, L., Baxter-Jones, A. D., Cameron, N., et al. (2015). Enhancing a somatic maturity prediction model. *Med. Sci. Sports Exerc.* 47, 1755–1764. doi: 10.1249/MSS.0000000000000588

Müller, L., Gehmaier, J., Gonaus, C., Raschner, C., and Müller, E. (2018). Maturity Status Strongly Influences the Relative Age Effect in International Elite Under-9 Soccer. *J. Sports Sci. Med.* 17, 216–222.

Patel, R., Nevill, A., Cloak, R., Smith, T., and Wyon, M. (2019). Relative age, maturation, anthropometry and physical performance characteristics of players within an Elite Youth Football Academy. *Int. J. Sports Sci. Coach.* 14, 714–725. doi: 10.1177/17479541198 79348

R Core Team (2018). *R: A Language and Environment for Statistical Computing.* Available online at: http://www.R-project.org/

Rubajczyk, K., and Rokita, A. (2018). The relative age effect in Poland's elite youth soccer players. *J. Hum. Kinet.* 64, 265–273. doi: 10.1515/hukin-2017-0200

Santos, A. J., and Gonçalves, C. E. (2012). Tradução do sources of enjoyment in youth sport questionnaire e do developmental assets profile para Jovens Atletas Portugueses. *Annals Res. Sport Phys. Act.* 3, 11–36.

Sarmento, H., Anguera, M. T., Pereira, A., and Araújo, D. (2018). Talent identification and development in male football: a systematic review. *Sports Med.* 48, 907–931. doi: 10.1007/s40279-017-0851-7

Semenick, D. (1990). Tests and measurements: the line drill test. *Strength Cond. J.* 12, 47–49. doi: 10.1519/0744-0049(1990)012<0047:TLDT>2.3.CO;2

Soares, A. L. A., Kós, L. D., Paes, R. R., Nascimento, J. V., Collins, D., Gonçalves, C. E., et al. (2020). Determinants of drop-out in youth basketball: an interdisciplinary approach. *Res. Sports Med.* 28, 84–98. doi: 10.1080/15438627.2019.1 586708

Stojanovic, E., Stojiljkovic, N., Scanlan, A. T., Dalbo, V. J., Berkelmans, D. M., and Milanovic, Z. (2018). The activity demands and physiological responses encountered during basketball match-play: a systematic review. *Sports Med.* 48, 111–135. doi: 10.1007/s40279-017-0794-z

Werneck, F. Z., Coelho, E. F., de Oliveira, H. Z., Ribeiro Júnior, D. B., Almas, S. P., de Lima, J. R. P., et al. (2016). Relative age effect in Olympic basketball athletes. *Sci. Sports* 31, 158–161. doi: 10.1016/j.scispo.2015.08.004

Wiersma, L. D. (2001). Conceptualization and development of the sources of enjoyment in youth sport questionnaire. *Meas. Phys. Educ. Exerc. Sci.* 5, 153–177. doi: 10.1207/s15327841mpee0503_3

Zuber, C., Zibung, M., and Conzelmann, A. (2016). Holistic patterns as an instrument for predicting the performance of promising young soccer players - A3-years longitudinal study. *Front. Psychol.* 7:1088. doi: 10.3389/fpsyg.2016.01088

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Talent Identification and Relative Age Effects in English Male Rugby Union Pathways: From Entry to Expertise

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A common practice in youth rugby union is to group players based on (bi)annual age with fixed cut-off dates. The overrepresentation of players born at the start of the cut-off date and the underrepresentation of players born toward the end of the cut-off date are termed relative age effects (RAEs). The aim of this study was to examine RAEs during entry into professional and international rugby union pathways in England, as well as comparing them to their respective senior cohort: U15 Regional Academy Player (n = 1,114) vs. Senior Professional Player (n = 281) and U16–23 England Academy Player (n = 849) vs. Senior International Player (n = 48). Chi-square (χ^2) analysis compared birth quarter (BQ) distributions against expected distributions. Odds ratios and 95% confidence intervals compared the likelihood of a BQ being selected. Findings revealed a significant overrepresentation of relatively older players compared with their relatively younger peers within both youth cohorts ($P < 0.001$; BQ1 = 42.5% vs. BQ4 = 9.6%; BQ1 = 36.5% vs. BQ4 = 15.2%). In comparison, there was no significant difference in the BQ distributions within both senior cohorts. Further, BQ4s were 3.86 and 3.9 times more likely to achieve senior professional and international levels than BQ1s and BQ2s, respectively. It is suggested that relatively younger players may have a greater likelihood of achieving expertise following entry into a rugby union talent pathway due to benefitting from more competitive play against relatively older counterparts during their development (e.g., reversal effects; the underdog hypothesis). Moreover, possible solutions (e.g., age and anthropometric banding; playing-up and playing-down) are discussed to encourage practitioners and policy makers to create the most appropriate learning environment for every player.

Keywords: Rugby Football Union, age-grade rugby, talent identification, talent development, player pathway

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INTRODUCTION

Identifying young rugby union players with the capabilities to achieve expertise at adulthood is a contemporary challenge for professional clubs and national governing bodies (Sherwood et al., 2019). Developmental pathways are mapped by academies and organizations to prepare youth players for the demands of professional and international rugby union (Parsonage et al., 2014).

However, the difficulty of accurately predicting future performance abilities, coupled with the complexities of the athlete development process, can result in biases during the recruitment process into talent development pathways (Baker et al., 2018; Till and Baker, 2020). One such selection bias that has been consistently highlighted in the literature is relative age effects (RAEs; Barnsley et al., 1985; Smith et al., 2018). RAEs illustrate that when athletes are banded according to (bi)annual-age groups, those who are born near the beginning of the selection year (e.g., September 1st in the United Kingdom) are often overrepresented compared with those who are born toward the end (e.g., August 31st; Cobley et al., 2009). Possible explanations that have been offered for this effect include the enhanced physiological and cognitive maturity of relatively older athletes, which allows them to outperform their younger age-matched peers (Doncaster et al., 2020). Further, Hancock et al. (2013a) proposed the social agents model to illustrate how RAEs are constructed in sport. This model suggests that social agents (e.g., parent, coaches, athletes) interpret factors, such as maturity, size, and skill, through their societal interactions, which in turn influence the quality of athletes' sport experiences. For instance, due to the "Matthew effect" (i.e., the rich get richer; Merton, 1968), parents are providing coaches with a pool of talented athletes, which is overloaded with relatively older athletes. Thus, coach selections related to relative age would be influenced by parental enrolment decisions (Hancock et al., 2013a).

Previous research suggests that the contact and invasive nature of rugby union may exacerbate the physiological advantages of those athletes who are chronologically older (Baker et al., 2009). Specifically, the rules and regulations of rugby union (e.g., tackling, running with the ball, ruck, scrum) are characterized by a broad range of physical factors, such as body size, speed, change of direction speed, high-intensity running ability, muscular strength, and power—all of which are crucial for player development (Till et al., 2020b). Thus, from an athlete development viewpoint, those born in birth quarter one (BQ1) of an annual-age group in England (i.e., September, October, November) may have developed more physically, cognitively, and socially than their later born BQ4 peers (i.e., June, July, August; Rubajczyk and Rokita, 2020). Due to the physical nature of rugby union, coaches may misconstrue older relative age, enhanced growth and maturation, and advanced fitness capacities at youth level as indicators for *performance* and *potential* (Hancock et al., 2013b; Furley and Memmert, 2016).

Skewed birthdate distributions among youth players favoring those born near the start of the cut-off date have been previously documented in rugby union (Musch and Grondin, 2001). From a recreational perspective, Lewis et al. (2015) found consistent RAEs across all age-grade and district cohorts from Under (U)7 to U19 (e.g., BQ1 = 29% vs. BQ4 = 22%). They also revealed an increasingly pronounced effect at U16 representative levels where regional and national selection occurs (e.g., BQ1 = 44% vs. BQ4 = 12%). Likewise, Roberts and Fairclough (2012) examined the North West of England representative squads from U13 to U16, illustrating a significant overrepresentation of those born in BQ1 (46%) compared with those born in BQ4 (14%). From an English Premiership rugby union academy outlook, McCarthy and Collins (2014) identified a significant overrepresentation of BQ1s (48%) compared with BQ4s (8%) in a single club. Collectively, these results suggest that the higher performance status of the youth level cohort, the more skewed the BQ distribution becomes.

RAEs in male rugby union have also been identified in other popular countries, such as Australia (Fernley, 2012), France (Delorme et al., 2009), New Zealand (Simons and Adams, 2017), and South Africa (Grobler et al., 2016). While exploring whether RAEs existed at the senior international level, Kearney (2017b) adopted a cross-cultural comparison as part of his methodology. In contrast to the youth case studies, he illustrated that only South Africa had pronounced RAEs across all playing positions at the senior level, suggesting that differences in national sport culture may be an important consideration while exploring who is at risk of RAEs. This also suggests that RAEs are considerably less prominent at senior levels than at youth levels in rugby union. Further, although these studies offer further evidence of RAEs, it is difficult for them to provide a true reflection of the England professional and international organizational structures on a national scale.

When exploring RAEs during the transition from academy to professional level at an English Rugby Premiership club, McCarthy and Collins (2014), McCarthy et al. (2016) identified a *reversal effect* of relative age. Specifically, they found that despite RAEs at the academy level favoring relatively older players (e.g., BQ1 = 48% vs. BQ4 = 8%), there was a greater proportion of relatively younger players who successfully converted to professional level (e.g., BQ1 = 20% vs. BQ4 = 50%). Furthermore, from a senior international level perspective, Jones et al. (2018) found that BQ1s were significantly underrepresented in 12 out of 14 criteria based on international caps and performance, whereas BQ4s were overrepresented in 8 out of 14 criteria (although this was not statistically significant). Jones et al. (2018) proposed that these late birthday benefits may be due to *survival of the fittest concept*s (e.g., Collins and MacNamara, 2012). Similar outcomes are apparent in other sports, such as rugby league (Till et al., 2016) and football (Kelly et al., 2020b), referred to as the *underdog hypothesis* by Gibbs et al. (2012). These studies illustrate the importance of combining both youth and senior representatives together to better understand who is at risk of RAEs, as well as identifying the potential mechanisms of the youth to senior level transitions. Furthermore, these studies also emphasize the need to identify RAEs along developmental trajectories to offer a greater longitudinal perspective. Indeed, the necessity of examining RAEs at more than one point in time is something that was recently encouraged by Schorer et al. (2020).

In this current study, the authors explored two English rugby union player pathways: (a) professional pathway—England Rugby Premiership (i.e., U15 Regional Academy Player to Senior Professional Player) and (b) international pathway—England Rugby Football Union (i.e., U16–U23 England Academy Player to Senior International Player). During the first pathway, academy programs are delivered *via* 14 Regional Academies (aligned with 12 England Rugby Premiership clubs, 1 England Rugby Championship club, and 1 unaffiliated). Individuals are typically identified from community or school rugby union and are selected to be a *U15 Regional Academy Player* from aged 14 years prior to potentially signing as a *Senior Professional Player* at aged 18 years (Till et al., 2020b). During the second pathway, certain individuals from the regional academy age groups who have displayed the potential to become a future senior professional or *Senior International Player* are selected to be a *U16–U23 England Academy Player*. The aim of this study was to explore the BQ distributions of the four cohorts within these two player pathways in England. Moreover, to examine the likelihood of achieving senior professional and international status, the Senior Professional Player cohort was compared against the U15 Regional Academy Player BQ distribution, whereas the Senior International Player cohort was compared against the U16–U23 England Academy Player BQ distribution.

METHODS

Sample and Procedure

Each player was allocated into one of the four cohorts based on their playing level: (a) U15 Regional Academy Player ($n = 1{,}114$), (b) Senior Professional Player ($n = 281$), (c) U16–U23 England Academy Player ($n = 849$), and (d) Senior International Player ($n = 48$). Every registered player during the last three seasons (i.e., 2016/17, 2017/18, 2018/19[1]) within these four cohorts participated in this study (total $n = 2{,}292$). In accordance with English annual-age group cut-off dates, this methodology divided the year into four 3-month BQs, starting with September 1st as *month 1* and ending with August 31st as *month 12*[2] (e.g., Till et al., 2009). Thus, each player was assigned a BQ corresponding to their birthdate to create an observed BQ distribution within each of the four cohorts. The observed BQ distributions from each cohort were subsequently compared against the expected BQ distribution calculated from average national live births (i.e., National Norms applied from the Office for National Statistics, 2015; see Delorme and Champely, 2015 for a review). To examine the likelihood of achieving senior professional and international status, further comparisons were provided for the two respective player pathways: (a) professional pathway and (b) international pathway. As such, the Senior Professional Player cohort was compared against the expected U15 Regional Academy Player BQ distribution, whereas the Senior International Player cohort was compared against the expected U16–U23 England Academy Player BQ distribution, respectively. The study was ethically approved at both organizational (England RFU) and institutional (Birmingham City University) levels.

[1]The three seasons applied to this study (i.e., 2016/17, 2017/18, 2018/19) include all the available data collected by the England Rugby Football Union for the U15 Regional Academy Player and U16–U23 England Academy Player cohorts. Thus, the last three season's data from the senior cohorts (i.e., Senior Professional Player and Senior International Player) were logically matched as a comparison.

[2]Non-Northern Hemisphere players' BQs were adjusted to reflect their rugby union affiliation cut-off dates with January 1st as *month 1* and ending with December 31st as *month 12*.

Data Analysis

A chi-square (χ^2) goodness of fit test was used to compare the BQ distributions of each cohort against the expected BQ distributions, following the procedures outlined by McHugh (2013). Since this test does not reveal the magnitude of difference between the BQ distributions for significant χ^2 outputs, Cramer's V was also used. The Cramer's V was interpreted as per conventional thresholds for correlation, whereby a value of 0.06 or more indicated a small effect size, 0.17 or more indicated a medium effect size, and 0.29 or more indicated a large effect size (Cohen, 1988). Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in order to compare the likelihood of each BQ being represented (CIs including 1 marked no association). Results were considered significant for $P < 0.05$.

RESULTS

There was a significant difference between the BQ distributions of the U15 Regional Academy Player cohort compared with the National Norms [χ^2 (df = 3) = 252.880, $P < 0.001$, V = 0.34]. The ORs showed an increased likelihood of relatively older players being selected, with the highest OR being BQ1 vs. BQ4 (4.23; 95% CI 3.38–5.77). Similarly, there was a significant difference between the BQ distributions of the U16–U23 England Academy Player cohort compared with the National Norms [χ^2 (df = 3) = 83.172, $P < 0.001$, V = 0.22]. The ORs showed an increased likelihood of relatively older players being selected, with the highest OR being BQ1 vs. BQ4 (2.40; 95% CI 1.82–3.17). However, there were no significant differences between the BQ distributions of both the Senior Professional Player and Senior International Player cohorts when compared with the National Norms (see **Table 1**).

When analyzing the respective pathways, there was a significant difference between the BQ distributions of the Senior Professional Player cohort compared with the expected U15 Regional Academy Player cohort [χ^2 (df = 3) = 82.358, $P < 0.001$, V = 0.38; see **Figure 1**]. When comparing the youth and senior distributions, the ORs showed an increased likelihood of relatively younger players achieving professional status, with the highest OR being BQ4 vs. BQ1 (3.86; 95% CI 2.27–6.56). Likewise, there was a significant difference between the BQ distributions of the Senior International Player cohort compared with the expected U16–U23 England Academy Player cohort [χ^2 (df = 3) = 14.851, $P = 0.002$, V = 0.39; see **Figure 2**]. When comparing the youth and senior distributions, the ORs showed an increased likelihood of relatively younger players achieving international status, with the highest OR being BQ4 vs. BQ2 (3.90; 95% CI 1.04–12.89).

DISCUSSION

The purpose of this study was to explore the BQ distributions of two youth (i.e., U15 Regional Academy Player and U16–U23 England Academy Player) and two senior (i.e., Senior Professional Player and Senior International Player) rugby union cohorts. Findings revealed that there was a significant

TABLE 1 | The BQ distributions of the professional and international pathways.

Cohort (National norms)	BQ1 (25.46%)	BQ2 (24.47%)	BQ3 (24.65%)	BQ4 (25.42%)	Total	χ2 (df = 3)	*P*	Cramer's V
U15 Regional Academy Player	474 (283.62)	311 (272.60)	222 (274.60)	107 (283.18)	1114	252.880	<0.001	0.34
U16-U21 England Academy Player	310 (216.16)	232 (207.75)	178 (209.28)	129 (215.82)	849	83.172	<0.001	0.22
Senior Professional Player	77 (71.54)	64 (68.76)	73 (69.27)	67 (71.43)	281	1.222	0.748	0.05
Senior International Player	12 (12.22)	6 (11.75)	17 (11.83)	13 (12.20)	48	5.124	0.163	0.23

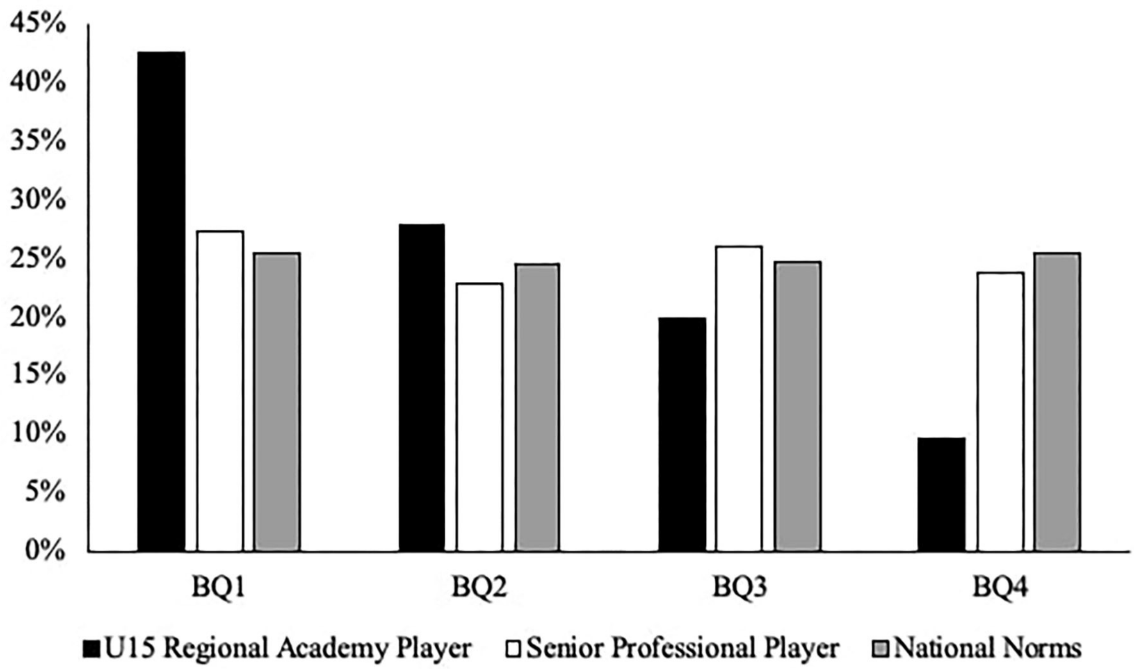

FIGURE 1 | The BQ distribution percentages of the professional pathway.

overrepresentation of players born earlier in the selection year compared with their later born peers within both of the youth cohorts (e.g., U15 Regional Academy Player—BQ1 = 42.5% vs. BQ4 = 9.6%; U16–U23 England Academy Player—BQ1 = 36.5% vs. BQ4 = 15.2%). However, there was no significant difference in the BQ distributions within both of the senior cohorts (e.g., Senior Professional Player—BQ1 = 27.4% vs. BQ4 = 23.8%; Senior International Player—BQ1 = 25% vs. BQ4 = 27.1%). Despite no RAEs prevalent at the senior levels, the skewed BQ distributions within both of the youth cohorts highlight that RAE differences exist along the professional and international rugby union pathways in England.

To examine the likelihood of achieving professional and international status based on existing distributions from youth and senior levels, further analysis compared the BQ distributions of the senior cohorts against the expected BQ distribution from their respective youth cohort. In the professional pathway, findings revealed that BQ4s were 3.86 times more likely to achieve professional status at senior level than BQ1s. Similarly, in the international pathway, findings revealed that BQ4s were 3.9 times more likely to achieve international status at senior level than BQ2s. Based on existing BQ distributions, this demonstrates that relatively later born players who are selected at youth level may be significantly more likely to achieve expertise at senior levels than their relatively earlier born peers.

This study adds a broader professional and international pathway lens to the existing literature in rugby union that explores RAEs. Indeed, these results resonate with previous youth rugby union research. Specifically, other studies in the United Kingdom have documented similar skewed BQ distributions at age-grade, regional, and academy youth levels, such as Lewis et al. (2015) (BQ1 = 29% vs. BQ4 = 23%), Roberts and Fairclough (2012) (BQ1 = 46% vs. BQ4 = 14%), and McCarthy and Collins (2014) (BQ1 = 48% vs. BQ4 =

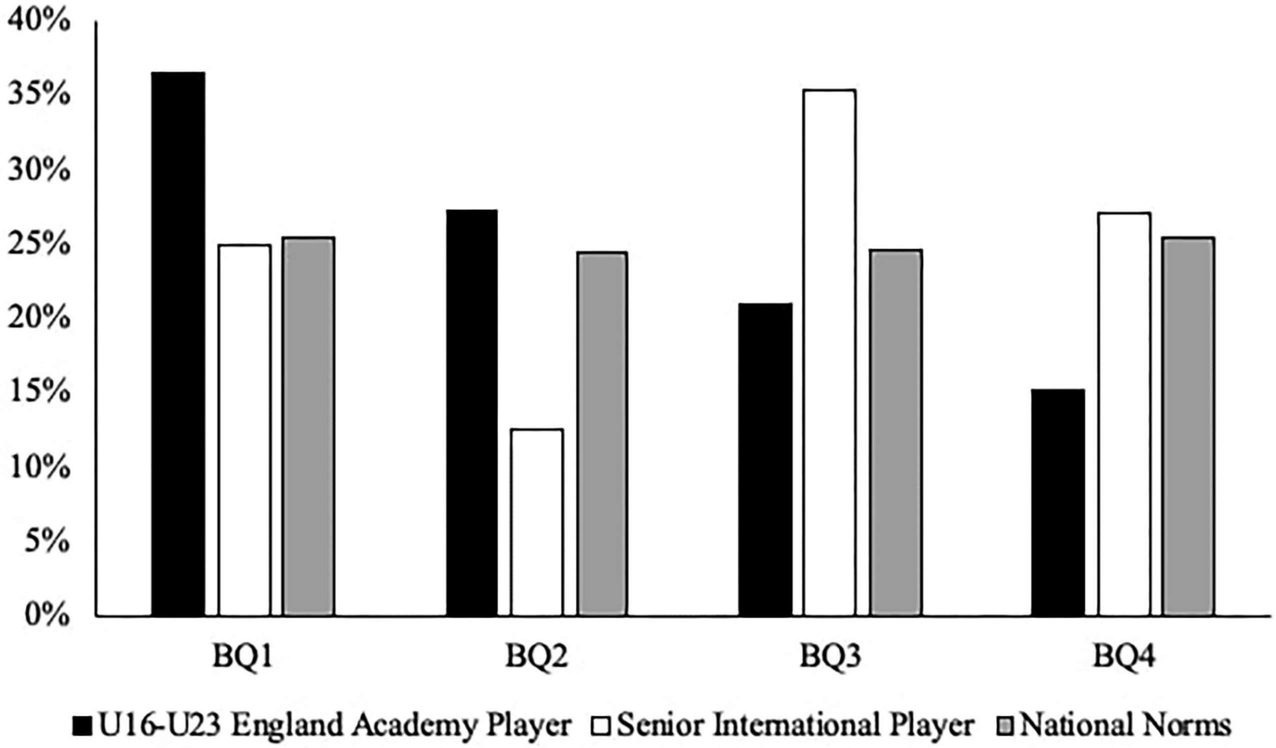

FIGURE 2 | The BQ distribution percentages of the international pathway.

8%), respectively. When exploring the playing level of these youth cohorts together, it appears that higher competition (e.g., regional, academy) may increase RAEs when compared with recreational level (e.g., age grade). This may be due to the competitive nature of high-performance rugby union, whereby athletes are selected based on current performance capabilities, rather than their ability to achieve expertise at senior level (Müller et al., 2015). Smith et al. (2018) have previously documented this trend in female sport during their systematic review, whereby they showed that significant OR estimates increased with playing level prior to senior competition. Thus, coaches and practitioners are encouraged to consider the long-term development outcomes of youth players when selecting at academy level, as opposed to solely focusing on existing performance abilities (Kelly and Williams, 2020). However, RAEs appeared to be more prevalent at the entry point of selection in the professional pathway at U15s than in the youth international pathway at U16–23s. Thus, key stakeholders who are recruiting players at the entry stage into academies should act with added caution.

This trend appears to continue into adulthood, whereby RAEs seem to be much less established (although less studied) at senior levels than at youth levels (e.g., Lemez et al., 2016; Kearney, 2017a,b). As such, selection at youth levels should logically turn to recruiting equal BQ distributions to reflect the opportunities presented at adulthood (Bennett et al., 2019). Although this current study does not identify players who have made the successful transition from youth to senior levels, it does identify their likelihood of transitioning based on the existing BQ distributions. Specifically, it was revealed that BQ4s have a greater likelihood of successfully transitioning from youth level to senior status than BQ1s. Moreover, the particularly lower proportion of BQ2s at senior international level also requires further inquiry. Thus, it is important to explore the potential mechanisms that facilitate such trends.

As an example, McCarthy and Collins (2014), McCarthy et al. (2016) suggest that a greater proportion of relatively younger players making the successful youth to senior transition may be due to a *reversal effect* of relative age. This is a psychologically based explanation of greater "growth" that relatively younger players experience, whereby they are initially disadvantaged during their development due to additional challenges they face (also see Jones et al., 2018). In addition, Gibbs et al. (2012) put forward the *underdog hypothesis* to highlight how relatively younger players are thought to benefit by more competitive play against relatively older counterparts throughout their development. Indeed, this may also be why there are a lower total number of senior international players born in the first half of the year (particularly in BQ2) than in the second half of the year. As such, it is important to consider how to create a "BQ4 effect" for those who may require such challenges during their development (Kelly et al., 2020b). Thus, every player should be exposed to the most appropriate settings to ensure that optimal long-term development outcomes are achieved, which can vary considerably between each individual (Abbott and Collins, 2004; Côté et al., 2014).

It is also important to note the considerably higher proportion of relatively older players (i.e., BQ1 or BQ2) who are being deselected or dropping out following the initial selection. Although relatively older players appear to be more likely to be recruited into talent development pathways (e.g., U15 Regional Academy Player, U16–U23 England Academy Player), it also seems that they comprise a greater quantity of players who are unsuccessful in achieving senior professional or international status. Thus, although relatively younger players have been reported to drop out of youth sport at young ages due to RAEs (e.g., Delorme et al., 2011), it may be suggested that this is being replicated by relatively older players at the latter stages of development during the youth to senior level transition. Moreover, Wattie et al. (2007) found that relatively older high-level ice hockey players were at increased risk of injury compared with their relatively younger peers. Due to the physicality of rugby union, it could be proposed that a similar instance of injury risk in relatively older players may suggest there is greater dropout at these ages, although further research is required to substantiate these claims. Thus, chronological age grouping may be providing a disservice to both relatively younger *and* relatively older players, although at different stages of the athlete development process. Overall, in light of these findings, it is important to consider solutions for RAEs and alternative group banding strategies to support relatively younger and relatively older players in youth rugby union.

Potential Relative Age Solutions

There is a small, but growing, body of literature that has attempted to develop solutions for RAEs (e.g., Cobley et al., 2019; Kelly et al., 2020a). Within annual-age groups for instance, Mann and van Ginneken (2017) designed an *age-ordered shirt numbering system* to reduce RAEs in youth soccer, revealing that supporting coaches and practitioners with the knowledge that the numbers on the playing shirts corresponded with the relative age of each athlete eliminated age bias. Bennett et al. (2019) recommended a *selection quota* to moderate RAEs, whereby governing bodies regulate their participating clubs to select a minimum number of players from each BQ. Tribolet et al. (2019) suggested *avoiding early deselection*, to allow continued exposure to practice, competition, and resources without the option of being released. Kelly et al. (2020b) proposed a *flexible chronological approach*, by offering early birth quartiles (i.e., BQ1s) and late birth quartiles (i.e., BQ4s) the opportunity to "play-up" and "play-down" annual-age groups, respectively. However, these suggestions are yet to be empirically evaluated in a rugby union setting. As such, future research should explore the practical implications of these strategies as solutions to moderate RAEs specifically within a youth rugby union context.

Research on alternative grouping strategies to moderate RAEs has been sparse compared with the large body of literature exemplifying its existence. In particular, where proposed grouping solutions have been suggested, little evidence has reported their effectiveness or tested attempts to directly implement them (Webdale et al., 2019). As an example, *proficiency level-based competition* in youth sport, such as the belts used in martial arts, may be a useful approach to moderate age-related performance advantages (Chiodo et al., 2011). By adopting such approach, athletes of the same chronological age will participate in regional, national, and international competitions that are balanced due to competing against those with the same "belt" or "color" (Chiodo et al., 2011). In taekwondo for instance, since athletes begin to compete at aged 10 years, youth competitions are based on a progression to meet the physiological characteristics of the children, to preserve them from an excessive physiological strain, as well as facilitate the development of their technical and tactical skills (Casolino et al., 2012). For this reason, Casolino et al. (2012) suggest how the Italian Taekwondo Federation establishes the proficiency level of youth athletes, through taking into account their training experience (i.e., from 1 to 3 years) and technical capabilities (i.e., belt or color). However, adopting such approach into team sports (e.g., rugby union) and its usefulness in moderating RAEs is yet to be examined; thus, further exploration is warranted.

One particularly interesting strategy may be utilized from the organizational practices adopted in youth American football. For instance, in contrast to many other team sports, previous research has identified no RAEs in American football, which may lend credibility to the *age and anthropometric* bandings that are often employed to group their young players (e.g., MacDonald et al., 2009; Jones et al., 2019). As such, the physical and collision-like nature of the two sports could suggest that American football regulations may provide a useful comparison in an endeavor to moderate RAEs in youth rugby union. As such, researchers are encouraged to further explore the impact of age and anthropometric banding and its impact on RAEs.

Another recent grouping approach that has produced promising results in reducing maturity-related differences in youth sport (particularly within soccer) is *bio-banding* (see Malina et al., 2019). Bio-banding groups athletes based on maturational indicators as well as anthropometric measures, which take into account individual variability in physical characteristics during early development (Cumming et al., 2017). For instance, during their maturity-matched soccer tournament, Bradley et al. (2019) revealed that later maturing players perceived the bio-banded format afforded more opportunities to express themselves, adopt positions of leadership, and have a greater influence on gameplay. Likewise, their early maturing but same-aged peers perceived the bio-banded games as more physically and technically challenging. In addition, preliminary studies have revealed that bio-banded competition may positively adapt the outcome of skill behaviors compared with annual-age group competition (e.g., Thomas et al., 2017; Abbott et al., 2019).

Together, these grouping strategies appear to logically address one of the key mechanisms of RAEs, whereby relatively older athletes are more likely to have an advanced maturity status (Webdale et al., 2019). Moreover, since growth and maturation status are positively related to physical capacities that are particularly important to youth rugby union (e.g., speed, muscular strength, power), anthropometric and biological bandings may further reduce the potential of physiological biases that are pronounced within chronological age groups (Webdale et al., 2019; Till et al., 2020b). However, Campbell et al. (2018) revealed that New Zealand youth rugby players were 46% more likely to drop out when they were bio-banded. They suggested that an increase in the aggressive style of play and the inability to participate with age-matched peers potentially contribute to dropout. These findings reinforce that in order for bio-banding to facilitate positive developmental experiences, the rugby union environment must be manipulated to harmonize with the young rugby players' needs.

It is also important to consider how bio-banding may look in youth rugby union contexts. Indeed, current studies have primarily focused their attention on academy soccer; thus, it is difficult to understand how it would be implemented within a rugby union setting, which comprises diverse talent development pathways (Till et al., 2020a). Overall, although these group banding approaches remain untested in their value for resolving RAEs, an introduction to grouping players by height, weight, and/or some maturational variables, alongside annual-age categories, may prove fruitful in mitigating RAEs in youth rugby union. As such, further research exploring alternative group banding strategies is warranted.

Limitations and Future Directions

The small sample size and inclusion of 3 years of retrospective data may be considered as potential limitations to this study. However, the authors worked collaboratively with an exhaustive database from the youth cohorts, while findings offer an accurate representation of the English professional and international pathways on a national scale. The current study also considered all players as one homogeneous group as position-specific data were not available. Since previous research exploring RAEs in senior rugby union has revealed inconsistent findings between playing positions (e.g., forwards vs. backs; Jones et al., 2018), further enquiry within a youth context is warranted. Moreover, while exploring the existing literature and considering the current study sample, female participants appear to be underrepresented across the discipline; thus, similar research within a female context is encouraged.

Future research should also explore the potential strategies to moderate RAEs in youth rugby union. For instance, annual-age group methods (e.g., age-ordered shirt numbering, selection quotas, avoiding early deselection, flexible chronological approach) and alternative group banding policies (e.g., age and anthropometric bands, bio-banding) could offer useful guidelines for organizations to adopt practical solutions. Further studies could also examine the underlying mechanisms of selection and progression throughout professional and international rugby union pathways, through qualitatively exploring key stakeholders' (e.g., players, coaches, practitioners) perceptions and experiences throughout the development process. As such, this may advance existing knowledge of the talent identification and development processes in rugby union (e.g., reversal effects, survival of the fittest concepts, underdog hypothesis).

CONCLUSION

There appears to be a complicated relationship between entry at youth levels and achieving expertise at senior levels in rugby union. The current findings reveal that, although there are no apparent RAEs throughout the senior cohorts, there are pronounced RAEs throughout the youth cohorts. This suggests that coaches and practitioners are selecting higher numbers of relatively older players at youth level, creating a bias based on older age and greater performance capabilities. Thus, those working in youth rugby union are encouraged to consider the long-term development outcomes of players when selecting at academy level, rather than focusing on existing abilities.

While exploring the likelihood of achieving senior professional and international status, there appears to be a greater chance of relatively younger players initially identified achieving professional or international level at adulthood. Therefore, it is important to consider *why* this may occur, as well as *how* to adapt existing structures to create the most appropriate learning environment for every player to achieve their full potential. As such, possible causes and solutions were presented to offer coaches and practitioners additional annual-age group strategies and alternative group bandings to mitigate RAEs in youth rugby union. However, there appears to be a paucity in research when practically implementing and empirically evaluating solutions for RAEs in rugby union. Thus, further collaboration between key stakeholders (e.g., players, coaches, practitioners) and researchers is required to explore the potential relative age strategies to facilitate greater positive youth development outcomes, as well as qualitatively examining the performance, participation, and personal development experiences of these individuals.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Birmingham City University. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

DJ, DB, and KB primarily focused on the Methods and Results sections, whereas AK, KT, and JT contributed more to the Introduction, Discussion, and Conclusion. All authors were involved with compiling the data, as well as writing the full manuscript.

REFERENCES

Abbott, A., and Collins, D. (2004). Eliminating dichotomy between theory and practice in talent identification and development: considering the role of psychology. *J. Sports Sci*. 22, 395–408. doi: 10.1080/02640410410001675324

Abbott, W., Williams, S., Brickley, G., and Smeeton, N. J. (2019). Effects of bio-banding upon physical and technical performance during soccer competition: a preliminary analysis. *Sports* 7, 193–204. doi: 10.3390/sports7080193

Baker, J., Schorer, J., Cobley, S., Bräutigam, H., and Büsch, D. (2009). Gender, depth of competition and relative age effects in team sports. *Asian J. Exercise Sports Sci*. 6, 7–13.

Baker, J., Schorer, J., and Wattie, N. (2018). Compromising talent: issues in identifying and selecting talent in sport. *Quest* 70, 48–63. doi: 10.1080/00336297.2017.1333438

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *CAHPER J*. 51, 23–28.

Bennett, K. J. M., Vaeyens, R., and Fransen, J. (2019). Creating a framework for talent identification and development in emerging football nations. *Sci. Med. Football* 3, 36–42. doi: 10.1080/24733938.2018.1489141

Bradley, B., Johnson, D., Hill, M., McGee, D., Kana-ah, A., Sharpin, C., et al. (2019). Bio-banding in academy football: player's perceptions of a maturity matched tournament. *Ann. Hum. Biol*. 46, 400–408. doi: 10.1080/03014460.2019.1640284

Côté, J., Turnnidge, J., and Evans, M. B. (2014). The dynamic process of development through sport. *Kinesiol Slovenica* 20, 14–26.

Campbell, E. C., Bracewell, P. J., Blackie, E., and Patel, A. K. (2018). The impact of Auckland junior rugby weight limits on player retention. *J. Sport Health Res*. 10, 317–326.

Casolino, E., Lupo, C., Cortis, C., Chiodo, S., Minganti, C., Capranica, L., et al. (2012). Technical and tactical analysis of youth taekwondo performance. *J. Strength Cond. Res*. 26, 1489–1495. doi: 10.1519/JSC.0b013e318231a66d

Chiodo, S., Tessitore, A., Cortis, C., Cibelli, G., Lupo, C., Ammendolia, A., et al. (2011). Stress-related hormonal and psychological changes to official youth Taekwondo competitions. *Scand. J. Med. Sci. Sports* 21, 111–119. doi: 10.1111/j.1600-0838.2009.01046.x

Cobley, S., Abbott, S., Eisenhuth, J., Salter, J., McGregor, D., and Romann, M. (2019). Removing relative age effects from youth swimming: the development and testing of corrective adjustments procedure. *J. Sci. Med. Sport* 22, 735–740. doi: 10.1016/j.jsams.2018.12.013

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med*. 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: L. Erlbaum Associates.

Collins, D., and MacNamara, Á. (2012). The rocky road to the top: why talent needs trauma. *Sports Med*. 42, 907–914. doi: 10.1007/BF03262302

Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C., and Malina, R. M. (2017). Bio-banding in sport: applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength Cond. J*. 39, 34–47. doi: 10.1519/SSC.0000000000000281

Delorme, N., Boich,é, J., and Raspaud, M. (2009). The relative age effect in elite sport. *Res. Q. Exercise Sport* 80, 336–344. doi: 10.1080/02701367.2009.10599568

Delorme, N., Chalabaev, A., and Raspaud, M. (2011). Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand. J. Med. Sci. Sports* 21, 120–128. doi: 10.1111/j.1600-0838.2009.01060.x

Delorme, N., and Champely, S. (2015). Relative age effect and chi-squared statistics. *Int. Rev. Sociol. Sport* 50, 740–746. doi: 10.1177/1012690213493104

Doncaster, G., Medina, D., Drobnic, F., Gómez-Díaz, A. J., and Unnithan, V. (2020). Appreciating factors beyond the physical in talent identification and development: insights from the FC Barcelona sporting model. *Front. Sports Act. Living* 2:91. doi: 10.3389/fspor.2020.00091

Fernley, P. D. (2012). *Relative Age Effects in Australian Junior Rugby Union*. Available online at: https://opus.lib.uts.edu.au/bitstream/2100/1374/2/02Whole.pdf (accessed April 2, 2020).

Furley, P., and Memmert, D. (2016). Coaches' implicit associations between size and giftedness: Implications for the relative age effect. *J. Sports Sci*. 34, 459–466. doi: 10.1080/02640414.2015.1061198

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. *Int. Rev. Sociol. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Grobler, T. D. T., Shaw, B. S., and Coopoo, Y. (2016). Relative age effect (RAE) in male school-aged rugby union players from Gauteng, South Africa. *Afr. J. Phys. Act. Health Sci*. 22:2.

Hancock, D. J., Adler, A. L., and Côt,é, J. (2013a). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci*. 13, 630–637. doi: 10.1080/17461391.2013.775352

Hancock, D. J., Ste-Marie, D. M., and Young, B. W. (2013b). Coach selections and the relative age effect in male youth ice hockey. *Res. Q. Exercise Sport* 84, 126–130. doi: 10.1080/02701367.2013.762325

Jones, B. D., Lawrence, G. P., and Hardy, L. (2018). New evidence of relative age effects in "super-elite" sportsmen: a case for the survival and evolution of the fittest. *J. Sports Sci*. 36, 697–703. doi: 10.1080/02640414.2017.1332420

Jones, C., Visek, A. J., Barron, M. J., Hyman, M., and Chandran, A. (2019). Association between relative age effect and organisational practices of American youth football. *J Sports Sci*. 37, 1146–1153. doi: 10.1080/02640414.2018.1546545

Kearney, P. E. (2017a). Playing position influences the relative age effect in senior rugby union. *Sci. Sports* 32, 114–116. doi: 10.1016/j.scispo.2016.06.009

Kearney, P. E. (2017b). The influence of nationality and playing position on relative age effects in rugby union: a cross-cultural comparison. *South Afr. J. Sports Med*. 29, 1–4. doi: 10.17159/2078-516X/2017/v29i1a4238

Kelly, A. L., Jackson, D. T., Taylor, J. J., Jeffreys, M. A., and Turnnidge, J. (2020a). "Birthday-banding" as a strategy to moderate the relative age effect: a case study into the England Squash Talent Pathway. *Front. Sports Act. Living* 2, 1–9. doi: 10.3389/fspor.2020.573890

Kelly, A. L., and Williams, C. A. (2020). Physical characteristics and the talent identification and development processes in youth soccer: a narrative review. *Strength Cond. J*. 42, 15–34. doi: 10.1519/SSC.0000000000000576

Kelly, A. L., Wilson, M. R., Gough, L. A., Knapman, H., Morgan, P., Cole, M., et al. (2020b). A longitudinal investigation into the relative age effect in an English professional football club: The 'underdog hypothesis'. *Sci. Med. Football* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Lemez, S., MacMahon, C., and Weir, P. (2016). Relative age effects in women's rugby union from developmental leagues to world cup tournaments. *Res. Q. Exercise Sport* 87, 59–67. doi: 10.1080/02701367.2015.1116120

Lewis, J., Morgan, K., and Cooper, S. M. (2015). Relative age effects in Welsh age grade rugby union. *Int. J. Sports Sci. Coach*. 10, 797–813. doi: 10.1260/1747-9541.10.5.797

MacDonald, D. J., Cheung, M., Côt,é, J., and Abernethy, B. (2009). Place but not date of birth influences the development and emergence of athletic talent in American football. *J. Appl. Sport Psychol*. 21, 80–90. doi: 10.1080/10413200802541868

Malina, R. M., Cumming, S. P., Rogol, A. D., Coelho-e-Silva, M. J., Figueiredo, A. J., Konarski, J. M., et al. (2019). Bio-banding in youth sports: background, concept, and application. *Sports Med*. 49, 1671–1685. doi: 10.1007/s40279-019-01166-x

Mann, D. L., and van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci*. 35, 784–790. doi: 10.1080/02640414.2016.1189588

McCarthy, N., and Collins, D. (2014). Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road? *J. Sports Sci*. 32, 1604–1610. doi: 10.1080/02640414.2014.908322

McCarthy, N., Collins, D., and Court, D. (2016). Start hard, finish better: further evidence for the reversal of the RAE advantage. *J. Sports Sci*. 34, 1461–1465. doi: 10.1080/02640414.2015.1119297

McHugh, M. L. (2013). The chi-square test of independence. *Biochem. Med*. 23, 143–149. doi: 10.11613/BM.2013.018

Merton, R. K. (1968). The Matthew effect in science. *Science* 159, 56–63. doi: 10.1126/science.159.3810.56

Müller, L., Hildebrandt, C., and Raschner, C. (2015). The relative age effect and the influence on performance in youth alpine ski racing. *J. Sports Sci. Med*. 14, 16–22.

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev*. 21, 147–167. doi: 10.1006/drev.2000.0516

Office for National Statistics (2015). *Number of Live Births by Date, 1995 to 2014, in England and Wales*. Available online at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/005149numberoflivebirthsbydate1995to2014inenglandandwales (accessed May 12, 2018)

Parsonage, J. R., Williams, R. S., Rainer, P., McKeown, I., and Williams, M. D. (2014). Assessment of conditioning-specific movement tasks and physical fitness measures in talent identified under 16-year-old rugby union players. *J. Strength Cond. Res*. 28, 1497–1506. doi: 10.1519/JSC.0000000000000298

Roberts, S. J., and Fairclough, S. J. (2012). The influence of relative age effects in representative youth rugby union in the North West of England. *Asian J. Exercise Sports Sci*. 9, 86–98.

Rubajczyk, K., and Rokita, A. (2020). The relative age effect and talent identification factors in youth volleyball in Poland. *Front. Psychol*. 11:1445. doi: 10.3389/fpsyg.2020.01445

Schorer, J., Roden, I., Büsch, D., and Faber, I. (2020). "Relative age effects are developmental! The necessity of looking at more than one time point," in *Relative age effects in sport: International perspectives,* eds J. C. Dixon, S. Horton, L. Chittle, and J. Baker (New York, NY: Routledge), 33–45.

Sherwood, S., Smith, T., and Masters, R. S. W. (2019). Pattern recall, decision making and talent identification in rugby union. *Eur. J. Sport Sci*. 19, 834–841. doi: 10.1080/17461391.2018.1545051

Simons, G., and Adams, L. (2017). The significance of birth dates of NZ 'All Blacks' – A comparison of the professional and amateur eras. *Scope*. 1, 164–170.

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med*. 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Thomas, C. H., Oliver, J., Kelly, A. L., and Knapman, H. (2017). A pilot study of the demands of chronological age group and bio-banded match play in elite youth soccer. *Grad. J. Sport Exercise Phys. Educ. Res*. 5:211.

Till, K., and Baker, J. (2020). Challenges and [possible] solutions to optimizing talent identification and development in sport. *Front. Psychol*. 11:664. doi: 10.3389/fpsyg.2020.00664

Till, K., Barrell, D., Lawn, J., Lazenby, B., Rock, A., and Cobley, S. (2020a). "'Wide and emergent - narrow and focussed': a dual-pathway approach to talent identification and development in England Rugby Union," in *Talent Identification and Development in Sport: International Perspectives,* eds J. Baker, S. Cobley, and J. Schorer (London: Routledge), 170–183.

Till, K., Cobley, S., Morley, D., O'Hara, J., Chapman, C., and Cooke, C. (2016). The influence of age, playing position, anthropometry and fitness on career attainment outcomes in rugby league. *J. Sports Sci*. 34, 1240–1245. doi: 10.1080/02640414.2015.1105380

Till, K., Cobley, S., Wattie, N., O'Hara, J., Cooke, C., and Chapman, C. (2009). The prevalence, influential factors and mechanisms of relative age effects in UK Rugby League. *Scand. J. Med. Sci. Sports* 20, 320–329. doi: 10.1111/j.1600-0838.2009.00884.x

Till, K., Weakley, J., Read, D. B., Phibbs, P., Darrall-Jones, J., Roe, G., et al. (2020b). Applied sport science for male youth rugby union in England. *Sports Med. Open* 6:14. doi: 10.1186/s40798-020-0236-6

Tribolet, R., Watsford, M. L., Coutts, A. J., Smith, C., and Fransen, J. (2019). From entry to elite: the relative age effect in the Australian football talent pathway. *J. Sci. Med. Sport* 22, 741–745. doi: 10.1016/j.jsams.2018.12.014

Wattie, N., Cobley, S., Macpherson, A., Howard, A., Montelpare, W. J., and Baker, J. (2007). Injuries in Canadian youth ice hockey: the influence of relative age. *Pediatrics*. 120, 142–148. doi: 10.1542/peds.2006-2672

Webdale, K., Baker, J., Schorer, J., and Wattie, N. (2019). Solving sport's "relative age" problem: a systematic review of proposed solutions. *Int. Rev. Sport Exercise Psychol.* 13:1–18. doi: 10.1080/1750984X.2019.1675083

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Leveling the Playing Field: A New Proposed Method to Address Relative Age- and Maturity-Related Bias in Soccer

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Despite various solutions proposed to solve the relative age effect (RAE), it is still a major problem confounding talent identification and selection processes. In the first phase, we sampled 302 under 7–21 academy soccer players from two Belgian professional soccer clubs to explore the potential of a new approach to solve the inequalities resulting from relative age- and maturity-related bias. This approach allocates players into four discrete quartile groups based on the midway point of their chronological and estimated developmental (ED) birth dates (calculated using the growth curves for stature of Belgian youth). With the use of chi square analyses, a RAE was found ($p < 0.01$) for the overall sample (Q1 = 41.4% vs. Q4 = 14.9%) that completely disappeared after reallocation (Q1 = 26.5%; Q2 = 21.9%; Q3 = 27.5%; Q4 = 24.2%). According to the new allocation method, the stature difference was reduced, on average, by 11.6 cm (from 24.0 ± 9.9 to 12.4 ± 3.4 cm, $d = 1.57$). Body mass difference between the two methods was 1.9 kg (20.1 ± 11.3–18.2 ± 13.1 kg, respectively, $d = 0.15$). The new method created a maximum chronological age difference of 1.9 vs. 0.8 years for the current method. With the use of this method, 47% of the players would be reallocated. Twenty-three percent would be moved up one age category, and 21% would be moved down. In the second phase, we also examined 80 UK academy soccer players to explore if reallocating players reduces the within-playing group variation of somatic and physical fitness characteristics. The percentage coefficient of variation (%CV) was reduced (0.2–10.1%) in 15 out of 20 metrics across U11–U16 age categories, with the U13 age category demonstrating the largest reductions (0.9–10.1%) in CV. The U12 and U13 age categories and associated reallocation groupings showed *trivial* to *small* (ES = 0.0–0.5) between-method differences and *trivial* to *moderate* (ES = 0.0–1.1) differences within the U14–U16 age categories. A reduction in RAE may lead to fewer dropouts and thus a larger player pool, which benefits, in turn, talent identification, selection, and development.

Keywords: relative age effect, maturity status, chronological birth date, developmental birth date, growth curve, allocation date, talent identification

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INTRODUCTION

The over-representation of soccer players born in the first 3 months (quartile) of the selection year is typically referred to as the relative age effect (RAE) (Cobley et al., 2009). This selection phenomenon has continued to confound talent identification since RAE was established (Barnsley et al., 1985). The RAE occurs within youth sports due to arbitrary annual age grouping [i.e., under (U)8, U9, and U10] with fixed cutoff dates in soccer that typically align with the calendar year (January 1 to December 31), except in the UK, where it is September 1 to August 30. Although these groupings are used to provide age-appropriate training and game formats, it does not account for the maturity-related differences within a given age category (Helsen et al., 2005) and can contribute to premature deselection and playing position allocation of soccer players (Towlson et al., 2017). Ultimately, it may confound the (de)selection processes that talent development centers employ, likely thwarting the size of the talent pool clubs that nations can select from.

The within age-group differences are a contributing factor for identifying players according to their relative (typically birth quartile), as opposed to chronological age. Categorizing players according to birth quartile has been shown to provide insight for practitioners when assessing anthropometrical and physical fitness-related characteristic differences within a chronologically categorized cohort of players (Cobley et al., 2009). This is of relevance and importance to talent development programs and national governing bodies, given that despite knowledge of the RAE spanning three decades (Helsen et al., 1998), a consistent over-representation of players born in the first and second quartiles of a selection year remains within development programs across the globe (Yagüe et al., 2020). The persistence of this within-year relative age selection phenomena is likely exacerbated by incentivized chronological age categorized match competitions (i.e., league tables and cups), spanning ages (between ∼10.7 and ∼15.2 years) associated with heightened periods of growth in stature [known as peak height velocity (PHV)] (Philippaerts et al., 2006; Towlson et al., 2018). In turn, this may result in large, temporary between-player maturity-related differences in physical and anthropometric characteristics, which may afford players born in quartiles 1 and 2 [who may also benefit from an early maturation (accelerated growth approximately 7.5 to 9.7 cm/year)] (Philippaerts et al., 2006; Towlson et al., 2018) a temporary physical and/or anthropometric advantage over their younger counterparts and likely further confound the (de)selection processes of practitioners (Philippaerts et al., 2006; Towlson et al., 2018). Obviously, these physical advantages often result in better performance and misrepresent the notion of "talent" at young ages. That said, some players born in the fourth quartile of the selection year may also be early developers and could potentially be compensated by advantages associated with advanced maturity that may result in perceived superior performance in "early competitive environments" and a subsequent selection bias in their favor (Helsen et al., 1998; Lovell et al., 2015; Yagüe et al., 2020).

In addition to within-year groups, the RAE can also transcend age groups establishing a between-year selection bias (Steingröver et al., 2017a). The between-year relative age selection phenomena have been shown to manifest in most national soccer teams and academy team selections, contributing typical over-selection (often four times more) of children born in the first quartile of the selection year in comparison with the last quartile (Barnsley et al., 1985; Barnsley and Thompson, 1988; Verhulst, 1992; Cobley et al., 2009; Nolan and Howell, 2010; Steingröver et al., 2017a). In current soccer systems, younger players are constantly trying to overcome selection bias throughout their development (particularly across adolescence), which is evidenced by the large dropout rates within popular team-sports such as soccer (Barnsley et al., 1985; Barnsley and Thompson, 1988; Verhulst, 1992; Helsen et al., 1998; Cobley et al., 2009; Nolan and Howell, 2010; Steingröver et al., 2017b). In addition, the between-year effect, which occurs when chronological age groups are aggregated (e.g., U10–U12–U14), (Schorer et al., 2013; Steingröver et al., 2017a), suggests that the older players are over-represented (e.g., in the U12 teams, there are more players who are 11 years old than players who are 10 years old).

Considering these findings, solutions to the RAE (Cobley et al., 2009) and maturity-associated selection biases (Cumming et al., 2017) have been suggested (for an overview of potential solutions, see Helsen and Starkes, 2020), which have included sport-specific cutoff dates (Musch and Hay, 1999; Musch and Grondin, 2001), nuanced talent identification strategies (Mann and van Ginneken, 2017), changing (Barnsley and Thompson, 1988; Helsen et al., 1998, 2012) and rotating the cutoff dates (Grondin et al., 1984; Barnsley and Thompson, 1988), accompanied by the Novem system, which implemented 9-month age categories (Boucher and Halliwell, 1991), and maturity status bio-banding (Cumming et al., 2018; Abbott et al., 2019; Romann et al., 2020; Towlson et al., 2020b). However, given the likely cross-age group disruption caused by some of the aforementioned interventions and the requirement for knowledge and experience in using complex maturity estimation algorithms (particularly when using bio-banding), it is perhaps not surprising that such interventions have failed in reducing the obvious persistence of the RAE and indeed maturity-selection bias worldwide, given the current rigid, chronologically aged ordered games and training programs within youth soccer (Yagüe et al., 2020). Therefore, the success of prospective interventions is seemingly highly dependent on complete league/national governing body support, which will permit flexibility for soccer academies to allocate players to a particular grouping on a semi-permanent [e.g., (half-) season long] with the option to systematically review the players' group status to an agreed schedule. Unfortunately, although different (but associated) (de)selection problems, the proposed "solutions" for reducing the RAE and/or the maturity selection bias have been ineffective thus far (although we acknowledge bio-banding research is its infancy). As a result, innovative, integrated research designs and strategies were proposed to eradicate such bias once and for all (Roberts et al., 2020). Therefore, the aim of this study was to propose and offer early examination of a new, relatively cheap, simple, and more practical way (i.e., absence of maturity estimation equations and/or player radiographs) ensuring that this new method of allocating youth players not solely using their chronological birth date, but also the estimated developmental (ED) birth date (based on their actual physical characteristics), is accessible to all levels of the soccer pyramid across the globe. Using two individual samples of academy soccer players, we specifically explored (1) if the midway point of the chronological and ED birth dates is an appropriate way to reallocate youth players (phase I) and (2) explore if the new method to reallocate players reduces the within-playing group variation of somatic and physical fitness characteristics within each group in comparison with traditional chronologically categorized categories using an independent sample of academy soccer players (phase II). This new cost-effective and simple method of reallocating players could potentially create a more stimulating climate for all players to develop throughout their career and decrease substantially the rate of dropout associated with the RAE.

METHODS

Phase I: Examination of the Midway Point Between the Chronological and Estimated Developmental Birth Dates to Reallocate Youth Players

Participants

A convenience sample of 302 male academy soccer players (U7: $n = 6$; U8: $n = 12$; U9: $n = 22$; U10: $n = 16$; U11: $n = 33$; U12: $n = 37$; U13: $n = 49$; U14: $n = 38$; U15: $n = 34$; U16: $n = 38$; U18: $n = 17$), participating in two different Belgian professional soccer academies (indicated as Team X and Team Y) during the 2019–2020 domestic soccer season, were sampled. The oldest player was born on January 16, 2003, and the youngest player was born on May 16, 2013. The sample size was constrained by the finite number of players available to recruit from across the two academies involved. Informed and parental/guardian consent were acquired for each player prior to testing, and a detailed protocol (MP013675) was approved by the Research Ethics Committee UZ/KU Leuven, Belgium.

Procedure

In line with previous publications (Helsen et al., 2005; Steingröver et al., 2017a), players were grouped within each category according to birth day quartile (Q) (Q1: January 1 to March 31; Q2: April 1 to June 30; Q3: July 1 to September 30; and Q4: October 1 to December 31) and expressed as a percentage of the sample population. The mean (95% confidence interval [CI]) age, stature, and body mass difference (delta) per age category and per team (**Table 1**) were established according to chronological (**Table 1A**) and ED birth dates (**Table 1A**). The ED birth date was estimated by comparing the anthropometric characteristics of each player with the normative growth curves from a longitudinal study examining secular changes in biological maturation in Belgian boys of the same age categories (Roelants et al., 2009).

Anthropometric Measures

Players' date of birth, the measurement date, and decimal age at the time of measurement were collected for each player. With the use of previously outlined procedures (Towlson et al., 2017), duplicate measurements of stature, seated height (0.1-cm precision, Seca© Portable Stadiometer, Hamburg, Germany), and body mass (0.1 kg, Seca©, Hamburg, Germany) of each player were collected. These measurements were performed by two certified practitioners of the respective clubs as part of their normal sports science monitoring. If the measurements varied $\geq$0.4 cm or 0.4 kg, a third measure was taken, and the median value recorded. Estimated leg length was recorded as stature minus seated height. **Tables 1A,B** provide an overview of the mean (95% CI) anthropometric characteristics per year for Team X and Team Y, respectively.

New Player Reallocation Method

With the use of the 50th percentile of the normal weight growth curve of the Belgian population (Roelants et al., 2009), the ED birth date was determined. This was established by plotting each player's stature on the corresponding 50th percentile curve to

TABLE 1A | Number of players and mean (95% CI) anthropometric characteristics per year for team X.

Year	*n*	Min stature (cm) (95% CI)	Max stature (cm) (95% CI)	Min body-mass (kg) (95% CI)	Max body-mass (kg) (95% CI)
2003 (U18)	16	168.0 (165.5–170.6)	180.2 (177.1–183.4)	58.9 (56.6–61.1)	71.9 (69.2–74.5)
2004 (U16)	18	166.5 (164.0–169.1)	178.6 (174.5 to182.8)	53.0 (51.9–54.1)	68.0 (63.6–72.5)
2005 (U15)	19	161.2 (158.2–164.2)	173.3 (170.8–175.9)	48.9 (47.1–50.8)	62.4 (58.6–66.2)
2006 (U14)	16	152.4 (148.6–156.3)	168.8 (165.4–172.2)	39.9 (38.4–41.5)	53.5 (51.4–55.7)
2007 (U13)	22	147.8 (146.2 to149.4)	157.8 (154.9 to160.6)	35.9 (35.2–55.6)	45.3 (43.4–47.1)
2008 (U12)	22	145.4 (143.5–147.2)	153.6 (152.0–155.2)	34.7 (34.3–35.2)	39.9 (39.4–40.5)
2009 (U11)	25	137.9 (136.3,139.5)	146.0 (144.9 to147.1)	30.7 (30.0–31.3)	37.4 (37.0–37.8)
Total	**138**	**152.4 (149.8–155.1)**	**164.1 (160.9–167.1)**	**41.7 (39.3–44.01)**	**52.6 (49.4–55.8)**

Key: Min, minimum; Max, maximum; CI, confidence interval; Kg, kilogram; cm, centimeter.

TABLE 1B | Number of players and mean (95% CI) anthropometric characteristics per year for team Y.

Year	*n*	Min stature (cm) (95% CI)	Max stature (cm) (95% CI)	Min body-mass (kg) (95% CI)	Max body-mass (kg) (95% CI)
2003 (U18)	1	174.5 (/)	174.5 (/)	56.8 (/)	56.8 (/)
2004 (U16)	20	166.6 (163.1–170.2)	178.2 (176.7–179.6)	54.1 (50.7–57.6)	71.6 (67.8–75.5)
2005 (U15)	15	162.6 (157.9–167.2)	178.0 (173.3–182.6)	81.0 (77.2–84.7)	90.2 (87.5–93.0)
2006 (U14)	22	154.4 (153.0 to155.7)	164.12 (160.9–167.3)	42.5 (41.4–43.7)	50.6 (47.6–53.5)
2007 (U13)	27	144.2 (142.2–146.3)	160.8 (157.1–164.5)	34.3 (32.9–35.6)	48.7 (44.4–52.9)
2008 (U12)	15	146.9 (144.4–149.4)	154.1 (151.1–157.0)	34.1 (33.1–35.2)	40.3 (37.9–42.6)
2009 (U11)	8	128.0 (123.92–132.08)	139.5 (133.0–145.9)	26.0 (23.0–28.9)	32.9 (29.9–35.9)
2010 (U10)	16	133.00 (130.3–135.7)	141.6 (139.0–143.6)	27.5 (25.9–29.2)	33.3 (31.7–34.8)
2011 (U9)	22	126.1 (124.23, 127.95)	135.2 (133.3, 137.1)	24.4 (23.6, 25.1)	29.0 (27.9, 30.0)
2012 (U8)	12	123.17 (121.4, 125.0)	126.3 (123.9, 128.8)	22.2 (21.6, 22.8)	25.6(24.2, 27.1)
2013 (U7)	6	112.00 (109.2, 114.8)	122.7 (119.2, 126.2)	19.0 (18.7, 19.4)	22.2(20.6, 23.8)
Total	**164**	**133.4 (131.4–135.4)**	**164.2 (162.0–166.4)**	**28.3 (27.3–29.4)**	**57.3 (53.6–61.0)**

Min, minimum; Max, maximum; CI, confidence interval; Kg, kilogram; cm, centimeter.

determine the player's ED age for stature (e.g., if a male player was 131-cm tall, his ED birth date is 8 years 2 months because 50% of the children are 131-cm tall considering a 1-month scale) (see **Figure 1**). Given that stature and body mass are highly correlated in this sample ($r = 0.876$; $p < 0.01$), only stature was used within the new allocation method. We acknowledge that during ages associated with post PHV, muscle mass develops at a faster tempo than stature (Towlson et al., 2018), likely due to enhanced levels of muscle growth hormones (Malina et al., 2004), accompanied by a greater proportion of training dedicated to developing strength and power (Ford et al., 2011). However, such enhanced rates in body mass growth (i.e., body mass > stature) likely coincide with a limited number of age categories (U16–U18) toward the upper end of our sampled population. Therefore, only stature was considered as the main reference point for our new allocation method in order to maintain simplicity, as this was considered a key objective in an attempt to reduce cross-age group disruption to games and training programs. Because the ED birth date could theoretically lead to age differences of up to 5 years with the child's chronological age (as will be shown below), the *median birth date* was calculated between the chronological and ED birth dates, which represented the new allocation date that was used to (re)allocate each player into a younger or older category or maintain the same age category. For instance, a U10 player with a calculated allocation date of 05/06/2011 was allocated to the U9 category. However, if the allocation date was 05/06/2009, then the player would be allocated to the U11 category. A customized spreadsheet was used to calculate the ED birth date. Following this, the number of players who either were reallocated (to either a higher or a lower team) or remained in the same age category was established, and a comparison was made between the aforementioned differences in the current selection method and the new allocation method with respect to stature, body mass, and age.

If the allocation date was based solely on ED birth date, then the age difference would become much larger. On average, there would be a 3.3-year difference between players in the same team, and the stature difference would be 6 cm on average. This could decrease the advantage for the younger player being the tallest because the oldest player could be more than 5 years older and just 5.5 cm shorter in the most extreme case as illustrated in **Figure 2**. The proposed new method for allocating players is expected to create a more "level playing field" by reducing the within-group variation of somatic and physical fitness characteristics, as its proposed that the new method will afford smaller players the opportunity to develop their talents in a fair way.

Phase II: Assessment of the Within-Group Variation of Somatic and Physical Fitness Characteristics Using Chronological and Estimated Developmental Birth Dates

Anthropometric and Maturation Status Measures

As stated in phase I, a convenience sample of 80 academy soccer players (U12: $n = 18$; U13: $n = 14$; U14: $n = 15$; U15: $n = 17$; U16: $n = 16$), participating in one UK professional soccer academy during the 2019–2020 domestic soccer, were considered. Player mean (95% CI) age, stature, and body mass difference (delta) per chronological age category (**Table 6**) and reallocation group (accompanied by ED birth data) were established using methods outlined in phase I. The same anthropometric variables from each player were recorded by one certified practitioner as stated in phase I (Towlson et al., 2017). Self-reported parental stature of both biological parents was also collected using previously outlined procedures (Cumming et al., 2018). To estimate maturation status, both biological parents self-reported their stature, which was adjusted for over-estimations using validated equation (Malina et al., 2007) based on measured and self-reported stature of US adults (Epstein et al., 1995), which provided an estimated percentage of final adult

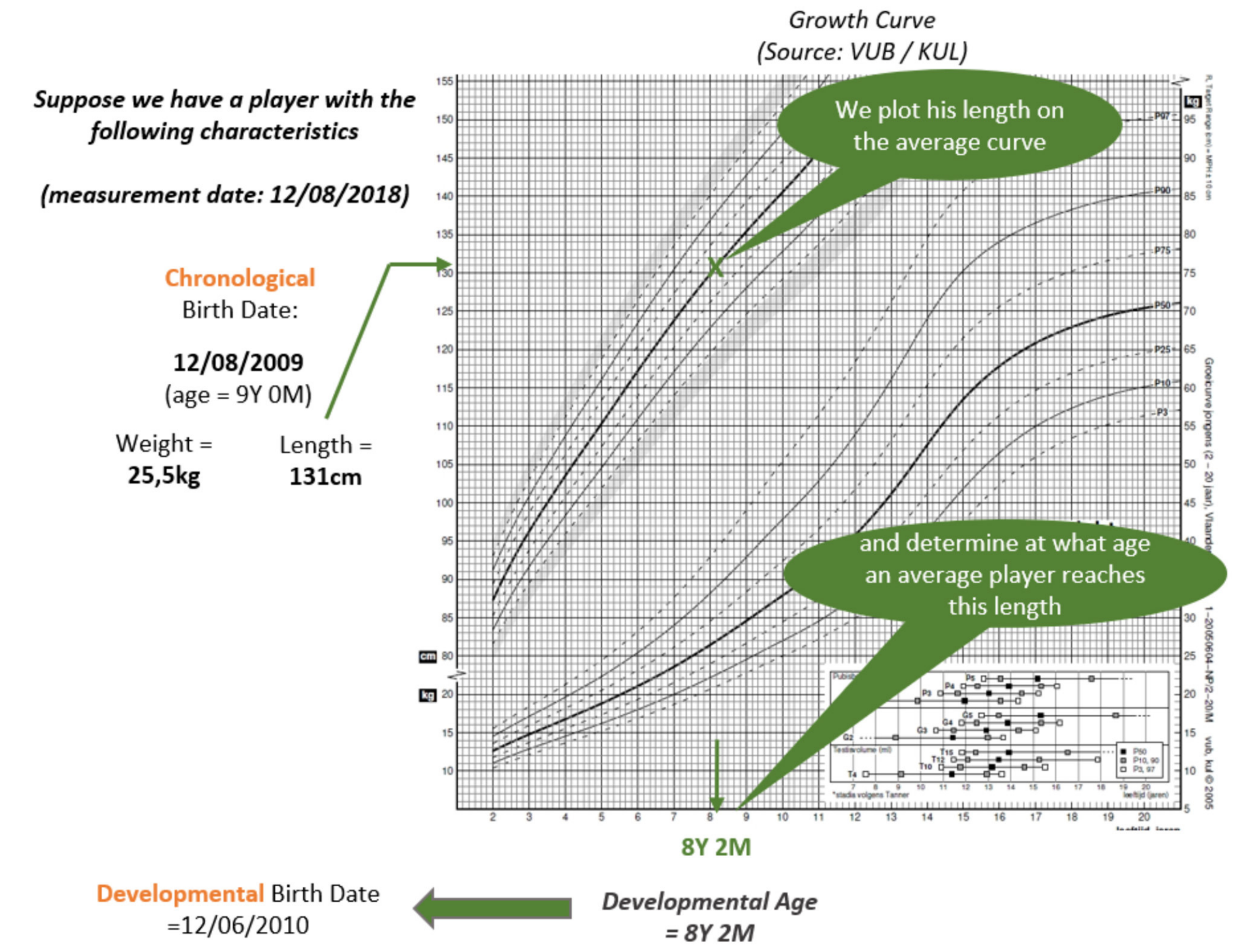

FIGURE 1 | Using the 50th percentile of the normal weight growth curve of the Belgian population (Roelants et al., 2009), the estimated developmental birth date was determined by plotting the player's stature on the corresponding 50th percentile curve to establish the player's estimated developmental age for stature.

stature attainment (%EASA), commonly used in academy soccer research (Abbott et al., 2019; Towlson et al., 2020a,b).

Physical Fitness Measures

Players performed a battery of field tests to reflect the level of perceived importance placed on power, acceleration speed, and agility by talent practitioners when considering physical qualities of academy soccer players during the selection process (Deprez et al., 2015; Towlson et al., 2019). Explosive lower limb power was assessed using a vertical counter-movement jump (CMJ) (Optojump, Microgate, Bolzano, Italy), according to previously outlined methods (Tanner and Gore, 2012). As per our previous studies (Towlson et al., 2017), players performed two CMJs interspaced by 1 min of passive recovery; and if the difference in jump heights differed more than 2 cm, a third jump was recorded (maximum of eight jumps) with the mean of the highest three jumps be recorded. Players also performed a stationary start, running acceleration test over 20 m using previously established methods (Tanner and Gore, 2012), which was expressed as the time taken to complete each split (i.e., 0–5, 0–10, and 0–20 m) using digital timing gates (Brower Timing System, Salt Lake City, Utah, USA). Players performed three repetitions, and the best time was recorded interspace by 3 min of passive recovery. Lastly, players' agility performance was assessed using the 5–0–5 agility test (Draper, 1985). From a stationary starting position, players were required to maximally accelerate for 15 m and then turn 180° and accelerate back to the start–finish line. The time taken to complete the final and first 5 m of each leg (10 m in total) was recorded using digital timing gates (Brower Timing System, Salt Lake City, Utah, USA). Players performed two repetitions, turning off each leg, and the best time was recorded.

Statistical Analyses

For phase I, a statistical analysis of the RAE was completed for the whole dataset as well as per age category. The statistical analyses included chi square, Kolmogorov–Smirnov, and a regression analysis. Because of the relatively small sample sizes especially

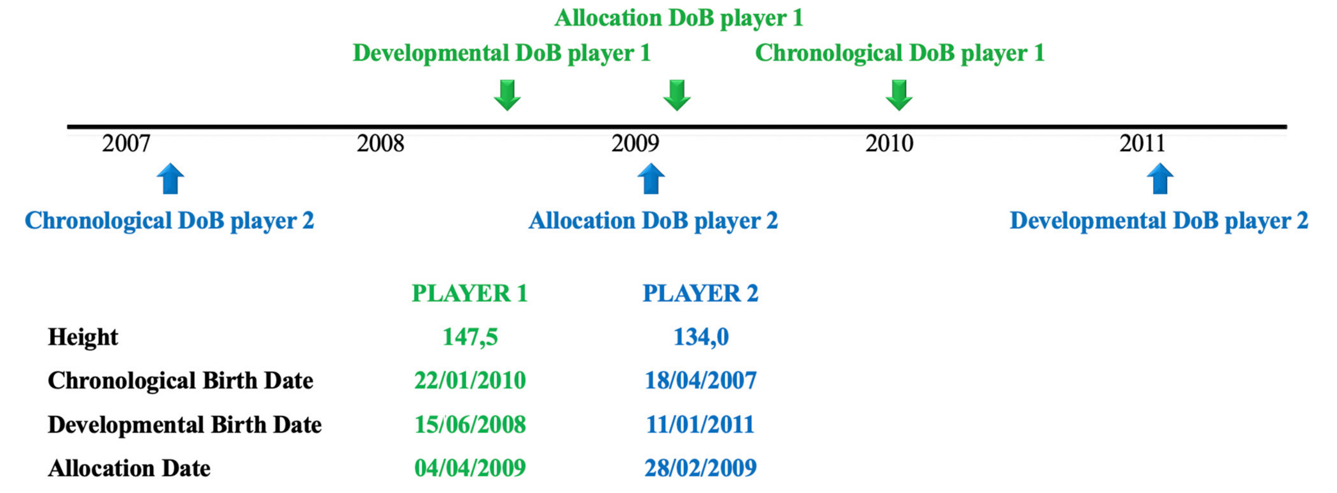

FIGURE 2 | Outcome of the new method that prescribes an appropriate developmental allocation date. Player 1 is currently playing in the U10 category and player 2 in the U12 category. After reallocation they are both allocated in the U11 category.

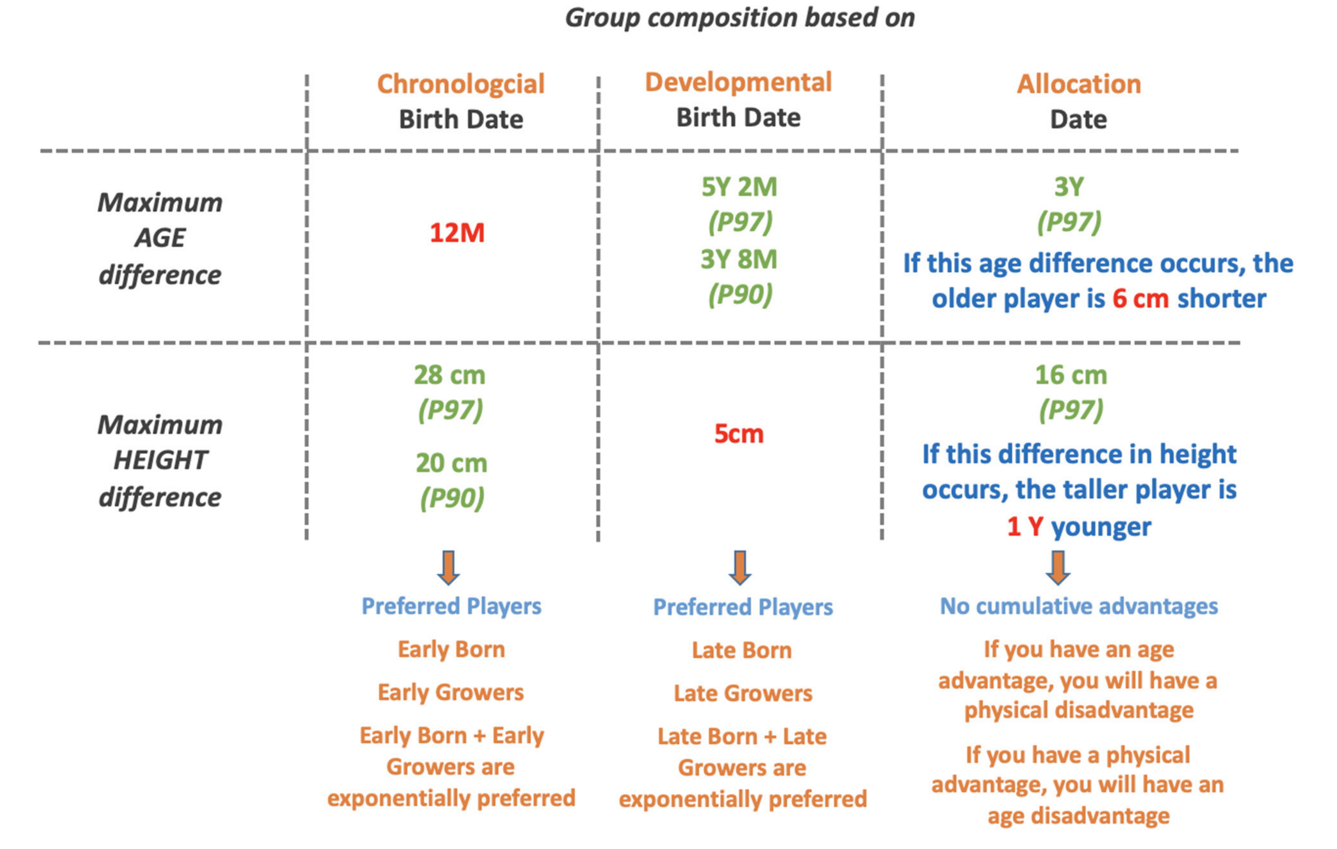

FIGURE 3 | Differences in age and physical development of U10 players for group compositions based on chronological birth date, developmental birth date, and allocation date.

in the younger categories, the age categories were grouped by aggregating two categories (i.e., U7 and U8). Mean and 95% CI were calculated for player stature and body mass. Effect sizes were calculated using Cohen's d, as appropriate. Cohen's d values for *small*, *medium*, and *large* effects are 0.20, 0.50, and 0.80, respectively (Cohen, 1988). Significance level for all tests was set at $p < 0.05$.

For phase II, the within-group variation for chronological and reallocation methods players, the percentage coefficient of variation (%CV) was calculated as the standard deviation

TABLE 2 | Overview of the anthropometrical and date of birth characteristics of 302 Belgian academy soccer players per age category for Team X and Y before reallocation.

Year	*n*	(Min stature (cm) % CI)	Max stature (cm) (95% CI)	Min body-mass (kg) (95% CI)	Max body-mass (kg) (95% CI)	Min DoB	Max DoB	Delta age (years)	Delta stature (cm)	Delta body-mass (kg)
2003	**17**	**168.73 (166.1, 171.4)**	**179.60 (176.6, 182.6)**	**58.63 (56.53, 60.74)**	**71.04 (68.46, 73.63)**	**16/01/2003**	**3/12/2003**	**0.9**	**24.7**	**26.5**
Team X	16	168.01 (165.5, 170.6)	180.24 (177.1, 183.4)	58.86 (56.63, 61.10)	71.85 (69.20, 74.50)	16/01/2003	3/12/2003	0.9	24.7	26.5
Team Y	1	174.5 (/)	174.5 (/)	56.8(/)	56.8(/)	11/08/2003	11/08/2003	0.0	0.0	0.0
2004	**38**	**166.43 (164.3, 168.6)**	**178.52 (176.5, 180.5)**	**53.52 (52.04, 54.99)**	**70.02 (67.10, 72.93)**	**7/01/2004**	**31/12/2004**	**1.0**	**34.5**	**38.1**
Team X	18	166.53 (164.0, 169.1)	178.63 (174.5,182.8)	53.03 (51.99, 54.08)	166.53 (164.02, 169.05)	7/01/2004	16/12/2004	0.9	34.2	35.3
Team Y	20	166.61 (163.1, 170.2)	178.15 (176.7, 179.6)	54.14 (50.69, 57.59)	71.61 (67.76, 75.46)	29/01/2004	31/12/2004	0.9	24.6	38.1
2005	**34**	**161.62 (159.1, 164.2)**	**175.56 (172.9, 178.2)**	**53.69 (51.23, 56.16)**	**84.26 (81.63, 86.89)**	**2/01/2005**	**21/12/2005**	**1.0**	**42.6**	**57.3**
Team X	19	161.19 (158.2, 164.2)	173.33 (170.8, 175.9)	48.96 (47.11, 50.81)	62.41 (58.65, 66.17)	14/01/2005	21/12/2005	0.9	28.0	33.5
Team Y	15	162.55 (157.9, 167.2)	177.95 (173.3, 182.6)	80.98 (77.22, 84.73)	90.21 (87.48, 92.95)	2/01/2005	7/08/2005	0.6	41.2	30.2
2006	**38**	**153.41 (151.6, 155.2)**	**166.25 (163.8, 168.7)**	**41.36 (40.49, 42.24)**	**51.88 (49.80, 53.97)**	**1/01/2006**	**11/12/2006**	**0.9**	**33.6**	**26.4**
Team X	16	152.41 (148.6, 156.3)	168.84 (165.4, 172.2)	39.96 (38.43, 41.49)	53.51 (51.38, 55.65)	4/01/2006	23/10/2006	0.8	33.6	25.9
Team Y	22	154.37 (153.0, 155.7)	164.12 (160.9, 167.3)	42.52 (41.37, 43.67)	50.56 (47.64, 53.49)	1/01/2006	11/12/2006	0.9	22.2	21.3
2007	**49**	**145.73 (144.2, 147.2)**	**159.52 (157.1, 162.0)**	**34.94 (34.24, 35.65)**	**47.18 (44.62, 49.74)**	**1/01/2007**	**27/11/2007**	**0.9**	**38.7**	**33.1**
Team X	22	147.76 (146.2,149.4)	157.79 (155.0,160.6)	35.85 (35.20, 55.65)	45.28 (43.44, 47.12)	2/01/2007	29/10/2007	0.8	24.6	19.4
Team Y	27	144.24 (142.2, 146.3)	160.77 (157.1, 164.5)	34.26 (32.89, 35.63)	48.65 (44.44, 52.86)	1/01/2007	27/11/2007	0.9	38.7	33.1
2008	**37**	**145.98 (144.4, 147.5)**	**153.79 (152.3, 155.3)**	**34.48 (33.90, 35.07)**	**40.11 (39.11, 41.10)**	**11/01/2008**	**25/12/2008**	**1.0**	**23.6**	**15.1**
Team X	22	145.35 (143.5, 147.2)	153.59 (152.0, 155.2)	34.75 (34.33, 35.18)	39.95 (39.38, 40.53)	13/01/2008	25/12/2008	1.0	19.6	10.8
Team Y	15	146.85 (144.4, 149.4)	154.06 (151.1, 157.0)	34.14 (33.05, 35.24)	40.26 (37.87, 42.64)	11/01/2008	28/09/2008	0.7	23.6	14.8
2009	**33**	**134.52 (132.3, 136.7)**	**145.52 (144.3, 146.8)**	**29.23 (28.44, 30.02)**	**36.71 (34.83, 38.58)**	**2/01/2009**	**30/12/2009**	**1.0**	**29.0**	**27.9**
Team X	25	137.91(136.3,139.5)	146.00 (144.9,147.1)	30.68 (30.03, 31.34)	37.42 (37.01, 37.84)	2/01/2009	25/11/2009	0.9	16.8	22.3
Team Y	8	128.00 (123.9, 132.1)	139.48 (133.0, 145.9)	25.95 (22.96, 28.94)	32.93 (29.93, 35.92)	19/01/2009	30/12/2009	0.9	29.0	16.2
2010	**16**	**133.00 (130.3, 135.7)**	**141.63 (139.7, 143.6)**	**27.53 (25.90, 29.15)**	**33.29 (31.74, 34.84)**	**12/01/2010**	**4/11/2010**	**0.8**	**20.5**	**12.5**
Team Y	16	133.00 (130.3, 135.7)	141.63 (139.7, 143.6)	27.53 (25.90, 29.15)	33.29 (31.74, 34.84)	12/01/2010	4/11/2010	0.8	20.5	12.5
2011	**22**	**126.09 (124.2, 128.0)**	**135.18 (133.3, 137.1)**	**24.36 (23.64, 25.08)**	**28.98 (27.94, 30.02)**	**3/01/2011**	**29/11/2011**	**0.9**	**22.0**	**9.7**
Team Y	22	126.09 (124.2, 128.0)	135.18 (133.3, 137.1)	24.36 (23.64, 25.08)	28.98 (27.94, 30.02)	3/01/2011	29/11/2011	0.9	22.0	9.7
2012	**12**	**123.17 (121.4, 125.0)**	**126.33 (123.9, 128.8)**	**22.17 (21.59, 22.75)**	**25.62 (24.15, 27.09)**	**16/01/2012**	**25/10/2012**	**0.8**	**10.0**	**7.6**
Team Y	12	123.17 (121.4, 125.0)	126.33 (123.9, 128.8)	22.17 (21.59, 22.75)	25.62 (24.15, 27.09)	16/01/2012	25/10/2012	0.8	10.0	7.6
2013	**6**	**112.00 (109.2, 114.8)**	**122.67 (119.2, 126.2)**	**19.03 (18.65, 19.42)**	**22.17 (20.58, 23.76)**	**9/01/2013**	**16/05/2013**	**0.3**	**18.0**	**4.7**
Team Y	6	112.00 (109.2, 114.8)	122.67 (119.2, 126.2)	19.03 (18.65, 19.42)	22.17 (20.58, 23.76)	9/01/2013	16/05/2013	0.3	18.0	4.7
Total	**302**	**139.10 (137.5, 140.7)**	**166.84 (165.5, 168.2)**	**31.59 (30.73, 32.44)**	**57.67 (55.70, 59.65)**	**16/01/2003**	**16/05/2013**	**0.8**	**24.0**	**20.1**

TABLE 3 | Physical characteristics of 302 Belgian academy soccer players, per age category and per team after reallocation.

Year	*n*	Min stature (cm)(95% CI)	Max stature (cm) (95% CI)	Min body-mass (kg) (95% CI)	Max body-mass (kg) (95% CI)	Min DoB	Max DoB	Delta age (years)	Delta stature (cm)	Delta body-mass (kg)
2002	**5**	**183.47 (182.0, 184.9)**	**188.23 (184.4, 192.1)**	**71.87 (70.1, 73.7)**	**79.27 (74.7, 83.8)**	**16/01/2003**	**7/01/2004**	**1.0**	**10.9**	**13.1**
Team X	5	183.47 (182.0, 184.9)	188.23 (184.4, 192.1)	71.87 (70.1, 73.7)	79.27 (74.74, 83.79)	16/01/2003	7/01/2004	1.0	10.9	13.1
2003	**21**	**172.94 (171.8, 174.1)**	**177.92 (176.3, 179.5)**	**63.45 (61.0, 66.0)**	**77.28 (71.3, 83.3)**	**31/01/2003**	**30/07/2005**	**2.5**	**20.9**	**43.8**
Team X	9	174.96 (173.6, 176.4)	180.38 (178.6, 182.2)	63.50 (59.4, 67.6)	69.68 (68.1, 71.2)	31/01/2003	26/06/2004	1.4	10.2	18.0
Team Y	12	177.13 (176.0, 178.2)	182.80 (178.9, 186.7)	63.68 (60.4, 67.0)	83.4 (75.2, 91.5)	11/08/2003	30/07/2005	2.0	19.0	41.7
2004	**34**	**165.56 (164.0, 167.1)**	**173.44 (172.2, 174.7)**	**55.47 (54.3,56.6)**	**68.78 (63.9,73.7)**	**6/03/2003**	**12/01/2006**	**2.9**	**17.1**	**43.6**
Team X	23	168.06 (166.5, 169.6)	175.02 (173.5, 176.5)	55.58 (54.4, 56.7)	64.40 (61.35, 67.45)	6/03/2003	12/01/2006	2.9	17.1	22.3
Team Y	11	171.87 (170.2, 173.5)	175.25 (174.6, 175.9)	55.33 (52.7, 58.0)	77.43 (67.0, 87.9)	4/02/2004	7/08/2005	1.5	8.8	43.6
2005	**33**	**157.71 (156.5, 159.0)**	**167.40 (166.4, 168.4)**	**50.68 (49.1,52.3)**	**69.56 (63.7,75.5)**	**4/02/2004**	**5/03/2007**	**3.1**	**14.2**	**42.3**
Team X	17	163.57 (162.1, 165.1)	169.72 (168.9, 170.6)	50.70 (49.4, 52.0)	59.22 (55.4, 63.0)	4/02/2004	23/10/2006	2.7	12.7	27.1
Team Y	16	162.74 (160.5, 165.0)	170.14 (168.9, 171.4)	51.36 (47.8, 55.0)	80.50 (74.8, 86.2)	15/05/2004	5/03/2007	2.8	14.2	42.3
2006	**37**	**151.41 (150.3, 152.5)**	**160.21 (158.5, 161.9)**	**43.42 (42.5,44.3)**	**56.78 (51.6,62.0)**	**8/01/2005**	**27/11/2007**	**2.9**	**17.2**	**44.6**
Team X	14	155.86 (153.7, 158.0)	163.14 (161.4, 164.9)	41.77 (40.3, 43.2)	48.80 (46.7, 50.90)	17/02/2005	14/10/2007	2.7	16.7	14.4
Team Y	23	155.76 (154.7, 156.8)	163.21 (161.2, 165.2)	44.64 (43.7, 45.6)	61.17 (54.1, 68.3)	8/01/2005	27/11/2007	2.9	15.8	41.5
2007	**41**	**149.55 (148.5, 150.6)**	**155.84 (154.6, 157.1)**	**36.57 (35.8, 37.4)**	**42.88 (41.5,44.2)**	**4/01/2006**	**22/09/2008**	**2.7**	**18.1**	**16.8**
Team X	24	149.13 (147.7, 150.6)	155.90 (154.4, 157.4)	36.48 (35.6, 37.3)	43.69 (41.7, 45.7)	4/01/2006	22/09/2008	2.7	16.1	16.5
Team Y	17	150.12 (148.9, 151.4)	155.76 (153.7, 157.8)	36.68 (35.2, 38.2)	41.79 (40.5, 43.1)	27/03/2006	5/04/2008	2.0	15.7	10.9
2008	**43**	**144.58 (143.8, 145.4)**	**150.07 (149.2, 150.9)**	**34.12 (33.6,34.7)**	**39.35 (38.0,40.7)**	**1/02/2007**	**1/07/2009**	**2.4**	**15.9**	**19.0**
Team X	23	145.44 (144.6, 146.3)	150.28(149.0, 151.5)	34.59 (33.7, 35.5)	40.43 (38.6, 42.3)	9/05/2007	1/07/2009	2.1	12.7	19.0
Team Y	20	143.55 (142.5, 144.6)	149.83 (148.8, 150.8)	33.77 (33.0, 34.5)	38.36 (36.3, 40.4)	1/02/2007	3/02/2009	2.0	14.1	14.6
2009	**25**	**138.26 (137.2, 139.3)**	**144.96 (143.9, 146.0)**	**30.62 (29.9, 31.3)**	**35.23 (34.4, 36.0)**	**18/04/2007**	**17/05/2010**	**3.1**	**15.0**	**9.1**
Team X	19	138.80 (137.5, 140.1)	144.95 (143.8, 146.1)	30.93 (30.1, 31.8)	35.55 (34.8, 36.3)	17/05/2008	3/11/2009	1.5	13.9	8.8
Team Y	6	137.33 (134.6, 140.0)	144.13 (140.6, 147.7)	30.03 (28.6, 31.5)	33.70 (31.4, 36.0)	18/04/2007	17/05/2010	3.1	13.5	8.4
2010	**23**	**133.13 (131.9, 134.4)**	**139.42 (138.7, 140.2)**	**27.81 (26.5, 29.1)**	**32.44 (31.3, 33.6)**	**10/03/2009**	**5/05/2011**	**2.2**	**12.5**	**12.5**
Team X	4	133.40 (132.9, 134.0)	137.35 (135.8, 138.9)	27.55 (27.5, 27.6)	33.90 (32.0, 35.8)	10/03/2009	25/11/2009	0.7	5.5	7.8
Team Y	19	133.25 (131.6, 134.9)	139.65 (138.9, 140.5)	28.23 (26.7, 29.8)	32.33 (31.0, 33.6)	20/09/2009	5/05/2011	1.6	12.5	12.5
2011	**21**	**127.18 (125.9, 128.5)**	**132.05 (130.9, 133.2)**	**24.25 (23.5, 25.0)**	**28.05 (27.3, 28.8)**	**31/10/2009**	**3/04/2012**	**2.4**	**14.5**	**9.1**
Team Y	21	127.18 (125.9, 128.5)	132.05 (130.9, 133.2)	24.25 (23.47, 25.04)	28.05 (27.34, 28.77)	31/10/2009	3/04/2012	2.4	14.5	9.1
2012	**13**	**122.14 (120.5, 123.8)**	**125.71 (124.9, 126.6)**	**22.36 (21.8, 22.9)**	**24.86 (23.8, 25.9)**	**8/06/2011**	**12/03/2013**	**1.8**	**8.0**	**6.8**
Team Y	13	122.14 (120.5, 123.8)	125.71 (124.9, 126.6)	22.36 (21.8, 22.9)	24.86 (23.8, 25.9)	8/06/2011	12/03/2013	1.8	8.0	6.8
2013	**5**	**115.67 (111.9, 119.4)**	**120.33 (119.8, 120.9)**	**19.47 (18.8, 20.2)**	**21.90 (20.5, 23.3)**	**25/10/2012**	**16/05/2013**	**0.6**	**9.0**	**4.2**
Team Y	5	115.67 (111.9, 119.4)	120.33 (119.8, 120.8)	19.47 (18.8, 20.2)	21.90 (20.5, 23.3)	25/10/2012	16/05/2013	0.6	9.0	4.2
2014	**1**	**109.00 (/)**	**109.00 (/)**	18.90 (/)	18.90 (/)	**21/04/2013**	**21/04/2013**	**0.0**	**0.0**	**0.0**
Team Y	1	109.00 (/)	109.00 (/)	18.90 (/)	18.90 (/)	21/04/2013	21/04/2013	0.0	0.0	0.0
Total	**302**	**138.83 (137.3, 140.4)**	**166.40 (165.0, 167.8)**	**36.54 (36.3, 36.8)**	**69.95 (68.2, 71.8)**	**16/01/2003**	**16/05/2013**	**1.9**	**12.4**	**18.2**

of the between-trial difference, divided by the mean between-trial difference. Data were presented as mean (95% CI) for each grouping; and Cohen's d values for *small*, *medium*, and *large* effects are 0.20, 0.50, and 0.80, respectively (Cohen, 1988), established for chronological vs. reallocation groupings with the accompanying qualities: trivial (<0.20), small (>0.21–0.60), moderate (>0.61–1.20), large (>1.21–2.00), and very large (>2.01) (Hopkins et al., 2009).

RESULTS

Results (Phase I)

Relative Age Effect

Figure 3 shows the birth date distribution per team and per quarter for all age categories before and after reallocation.

For the total dataset before reallocation (**Figure 3A**), there was a significant difference in distribution of players between the observed and expected birth date distributions (based on the Belgian population for the corresponding years). Most players were born in the first quarter ($\chi^2 = 53.48$; $p < 0.01$). This result was also supported by the result of a Kolmogorov–Smirnov analysis ($p < 0.01$) and a regression analysis ($r = -0.84$; $p < 0.01$). The aggregated age groupings (i.e., U7–U8 and U9–U10) demonstrated that a RAE was present compared with the population norm distributions ($p < 0.01$; Q1 = 44.4 and 36.8%; Q4 = 5.6–10.5%) except for the U11–U12 group ($\chi^2 = 5.06$; $p > 0.05$; $r = -0.55$ $p < 0.05$; Q1 = 35.7%; Q4 = 18.6%). **Table 2** shows the anthropometrical characteristics of each team according to age category accompanied by the mean (95% CI) and deltas. The difference between the tallest and smallest players in the younger categories was 18.0 (U7), 10.0 (U8), 22.0 (U9), 20.5 (U10), 29.0 (U11), and 23.6 cm (U12) and was enhanced within the older age categories to 38.7 (U13), 33.6 (U14), 42.6 (U15), 34.5 (U16), and 24.7 cm (U18). The mean difference between minimal and maximal age is 0.8 years; for stature, it is 24.0 cm; and the mean difference in body mass was 20.1 kg. Stature and body mass demonstrated a *strong* correlation ($r = 0.876$; $p < 0.01$).

Effect of Reallocation

Following application of the new reallocation method (**Figure 3B**), differences disappeared for the number of players per birth date quarter as shown in **Figure 3B**. For both teams, each quarter was now composed of approximately 25% of the players (Q1 = 26.5%; Q2 = 21.9%; Q3 = 27.5%; Q4 = 24.2%).

In **Table 3**, the newly allocated teams are shown. Again, data are divided per team, and the deltas for age, stature, and body mass are given. The stature and body mass differences became greater with age within each group. The average deltas are now 1.9 years, 12.4 cm, and 18.2 kg.

The age difference was corrected because of reallocation. If a player is older, this player is usually the smallest. And the youngest player is usually the tallest. This is demonstrated in **Table 4**. The oldest player was born on 18/04/2007 and has a stature of 134 cm (on the growth curves, this stature corresponds with the P50 for almost 9 years old), whereas the youngest player was born on 22/01/2010 but is 147.5-cm tall (on the growth curves, this corresponds with 11-year-olds). Due to this change, a taller player might have a physical advantage over the older player. Obviously, the older player could have enhanced cognitive skills, which in turn could compensate for the stature difference.

TABLE 4 | Player distribution of a sampled U11 Belgian academy soccer team, where the tallest player is also the youngest player.

U11		
Birth date	**Stature**	**Allocation date**
18/04/2007	134.0	15/03/2009
11/01/2008	138.5	21/03/2009
17/05/2008	140.2	7/04/2009
14/08/2008	144.3	21/03/2009
24/11/2008	139.2	11/05/2009
2/01/2009	135.1	29/11/2009
19/01/2009	139.9	26/07/2009
15/02/2009	142.5	6/04/2009
2/03/2009	139.1	28/09/2009
6/03/2009	146.1	31/03/2009
12/03/2009	139.8	3/09/2009
12/03/2009	146.4	2/01/2009
2/04/2009	146.4	15/03/2009
29/04/2009	145.2	13/07/2009
3/05/2009	145.3	28/01/2009
7/06/2009	137.4	16/12/2009
7/06/2009	144.2	2/04/2009
10/07/2009	142.7	2/09/2009
18/07/2009	144.1	22/05/2009
27/07/2009	140.7	11/08/2009
30/07/2009	136.2	12/10/2009
21/10/2009	149.0	22/02/2009
3/11/2009	143.7	15/06/2009
22/01/2010	147.5	19/04/2009

In **Table 5**, the category changes are displayed that result from this new allocation method. Forty-seven percent of the players would be allocated to a different age category compared with the current one. One percent would be reallocated two age categories lower, 21% would be reallocated one age category lower, 23% would be reallocated one age category higher, and just 2% would be reallocated two age categories higher. For Team X, the percentage of players that are not reallocated is 56%, whereas for Team Y, 51% of the players would not be reallocated. However, the dataset received from Team Y was slightly bigger, so in reality the results can be considered comparable.

Results (Phase II)

The mean ± SD (95% CI) and associated effect sizes for physical and anthropometric characteristics according to traditional, chronologically ordered vs. the proposed reallocation method for categorizing players are displayed in **Table 6**. For the 20 comparisons exploring the impact of the reallocation, group CV was reduced (0.2–10.1%) in 15 metrics across U11 to U16 age categories, with the U13 age category demonstrating the largest reductions (0.9–10.1%) in CV (see **Figures 4**, **5**). The U12 and

TABLE 5 | Overview of the category changes that result from the new allocation method, as well as the percentage of players who are not reallocated for ## Belgian academy soccer players.

Year	2 teams down	1 team down	Same team	1 team up	2 teams up	Total	Not reallocated (%)
2003		7	6	4		17	35
Team X		7	5	4		16	31
Team Y			1			1	100
2004		9	16	12	1	38	42
Team X		4	9	4	1	18	50
Team Y		5	7	8		20	35
2005		7	14	10	3	34	41
Team X		4	9	6		19	47
Team Y		3	5	4	3	15	33
2006		8	20	9	1	38	53
Team X		4	7	4	1	16	44
Team Y		4	13	5		22	59
2007	1	13	24	10	1	49	49
Team X		4	15	3		22	68
Team Y	1	9	9	7	1	27	33
2008		3	25	9		37	68
Team X		2	15	5		22	68
Team Y		1	10	4		15	67
2009	1	9	18	5		33	55
Team X		4	17	4		25	68
Team Y	1	5	1	1		8	13
2010		3	10	3		16	63
Team Y		3	10	3		16	63
2011		3	15	4		22	68
Team Y		3	15	4		22	68
2012		1	9	2		12	75
Team Y		1	9	2		12	75
2013		1	4	1		6	67
Team Y		1	4	1		6	67
Total	**2**	**64**	**161**	**69**	**6**	**302**	**53**

U13 age categories and associated reallocation groupings showed *trivial* to *small* (ES = 0.0–0.5) between-method differences. With *trivial* to *moderate* (ES = 0.0–1.1) differences within the U14–U16 age categories.

DISCUSSION

The primary aim of this study was to examine to what extent a new method of player allocation based on an ED age, using the midway point of the chronological and developmental birth dates, could provide a solution to decrease and, ultimately, to solve the RAE and maturity-related bias. With the use of two separate academy soccer player datasets, the new allocation method was explored. The findings of the present study were four-fold: (1) the current age distribution per team and per quartile was similar to the distribution in literature and clearly showed a RAE for the entire sample of players (Barnsley et al., 1985; Verhulst, 1992; Helsen et al., 1998, 2000, 2012; Hurley et al., 2001; Musch and Grondin, 2001; Cobley et al., 2009; Nolan and Howell, 2010; Christina Steingröver et al., 2017a); (2) the RAE was also calculated for aggregate age groupings (e.g., U13 and U14), and in almost all groups (except U11–U12), a RAE was present; (3) with the use of the new allocation method, 47% ($n = 141$) of players would have been allocated to a different age playing category compared with the current system. (4) Fifteen of the 20 (75%) observed between-method comparisons show that the reallocation method reduced group CV, which was consistent for anthropometric and maturation status characteristics for all of the sampled age categories. Given the two-part design of the study, we will now discuss these findings separately beginning with phase I.

Phase I: Examination of the Midway Point Between the Chronological and Estimated Developmental Birth Dates to Reallocate Youth Players

Regarding the first point, the magnitude of the RAE was a factor of "four" for the overall sample of youth players (Q1 = 41.4 vs.

TABLE 6 | Summary table of mean ± SD (95% CI) and effect sizes for physical and anthropometrical characteristics of 80 UK academy soccer players (U12–U16) according to traditional chronologically ordered and the proposed reallocation method.

Banding method	**Chronological banding**	**Reallocation method**	**Effect size**	**Chronological banding**	**Reallocation method**	**Effect size**	**Chronological banding**	**Reallocation method**	**Effect size**	**Chronological banding**	**Reallocation method**	**Effect size**	**Chronological banding**	**Reallocation method**	**Effect size**
Age grouping	**U12**	**U12**	**U12**	**U13**	**U13**	**U13**	**U14**	**U14**	**U14**	**U15**	**U15**	**U15**	**U16**	**U16**	**U16**
	(n = 7)	**(n = 7)**		**(n = 11)**	**(n = 8)**		**(n = 15)**	**(n = 11)**		**(n = 12)**	**(n = 11)**		**(n = 11)**	**(n = 10)**	
Metrics															
Stature (cm)	149.0 ± 6.2 (146.1–151.8)	149.4 ± 3.6 (147.5–151.2)	0.1, Trivial	159.2 ± 9.9 (146.1–151.8)	158.2 ± 3.3 (155.9–160.5)	0.2, Trivial	167.5 ± 7.3 (163.8–171.2)	163.9 ± 5.3 (160.9–166.9)	0.6, Small	176.1 ± 6.2 (172.7–179.6)	171.3 ± 2.9 (169.8–172.9)	0.9, Moderate	179.8 ± 6.3 (176.6–182.9)	174.7 ± 2.7 (173.1–176.4)	1.1, Moderate
CV (%)	4.2	2.4		6.2	2.1		4.3	3.2		4.1	1.7		3.5	1.5	
Mass (kg)	37.5 ± 6.2 (35.3–39.6)	39.9 ± 3.6 (36.0–39.8)	0.1, Trivial	46.6 ± 9.1 (41.8–51.4)	44.1 ± 4.1 (41.2–46.9)	0.4, Small	52.1 ± 7.8 (48.2–56.1)	49.6 ± 5.6 (46.4–52.7)	0.4, Small	63.0 ± 6.8 (59.8–66.3)	58.4 ± 6.8 (54.8–62.0)	0.7, Moderate	66.4 ± 4.4 (64.2–68.6)	64.6 ± 3.8 (62.2–67.0)	0.4, Small
CV (%)	12.7	9.6		19.5	9.4		15.0	11.3		10.9	11.7		6.7	6.0	
CMJ (cm)	24.9 ± 3.8 (22.1–27.6)	25.8 ± 2.1 (24.3–27.3)	0.3, Small	28.2 ± 3.1 (26.3–30.0)	28.0 ± 2.9 (25.1–30.8)	0.1, Trivial	28.9 ± 4.2 (26.8–30.0)	28.9 ± 4.6 (26.2–31.6)	0.0, Trivial	35.6 ± 4.5 (33.0–38.1)	30.5 ± 4.5 (27.7–33.2)	1.1, Moderate	38.4 ± 4.7 (35.6–41.1)	36.4 ± 3.4 (34.2–38.6)	0.5, Small
CV (%)	15.1	8.1		11.0	10.3		14.5	15.7		12.7	14.9		12.3	9.2	
COD (sec)	2.8 ± 0.1 (2.7–2.9)	2.7 ± 0.1 (2.7–2.8)	0.4 Small	2.7 ± 0.1 (2.6–2.7)	2.7 ± 0.1 (2.6–2.8)	0.1, Trivial	2.6 ± 0.1 (2.5–2.6)	2.6 ± 0.1 (2.6–2.7)	0.5, Small	2.5 ± 0.1 (2.5–2.6)	2.5 ± 0.1 (2.5–2.6)	0.2, Trivial	2.4 ± 0.1 (2.4–2.5)	2.4 ± 0.1 (2.4–2.5)	0.3 Small
CV (%)	4.4	3.6		4.0	3.4		5.4	5.0		3.7	4.8		3.4	2.1	
5m (sec)	1.1 ± 0.1 (1.1–1.1)	1.1 ± 0.0 (1.1–1.1)	0.0, Trivial	1.1 ± 0.0 (1.0–1.1)	1.1 ± 0.0 (1.1–1.1)	0.4, Small	1.0 ± 0.1 (1.0–1.1)	1.1 ± 0.0 (1.0–1.1)	0.0, Trivial	1.0 ± 0.0 (0.9–1.0)	1.0 ± 0.1 (1.0–1.0)	0.9, Moderate	1.0 ± 0.0 (1.0–1.0)	0.9 ± 0.0 (0.9–1.0)	1.0, Moderate
CV (%)	5.5	4.2		3.4	3.3		5.3	3.9		4.6	5.0		4.8	3.1	
10m (sec)	1.9 ± 0.1 (1.9–2.0)	1.9 ± 0.1 (1.9–2.0)	0.4, Small	1.9 ± 0.1 (1.8–1.9)	1.8 ± 0.0 (1.8–1.9)	0.0, Trivial	1.8 ± 0.1 (1.8–1.9)	1.9 ± 0.1 (1.8–1.9)	0.8, Moderate	1.7 ± 0.1 (1.7–1.8)	1.8 ± 0.1 (1.7–1.8)	0.3, Small	1.7 ± 0.1 (1.7–1.8)	1.7 ± 0.1 (1.7–1.7)	0.1, Trivial
CV (%)	4.0	3.1		3.4	2.0		5.0	4.2		3.6	4.2		5.0	3.1	
20m (sec)	3.5 ± 0.2 (3.3–3.6)	3.4 ± 0.1 (3.3–3.5)	0.4, Small	3.3 ± 0.1 (3.2–3.3)	3.3 ± 0.1 (3.2–3.4)	0.0, Trivial	3.2 ± 0.1 (3.2–3.3)	3.3 ± 0.1 (3.2–3.3)	0.6, Small	3.0 ± 0.1 (3.0–3.1)	3.1 ± 0.1 (3.1–3.2)	0.7, Moderate	2.9 ± 0.1 (2.9–3.0)	2.9 ± 0.1 (2.9–3.0)	0.2, Small
CV (%)	5.8	3.6		2.9	2.3		3.8	3.4		4.2	3.7		4.3	3.7	
EASA (%)	82.6 ± 1.6 (81.8–83.3)	82.9 ± 1.4 (82.2–83.7)	0.2, Small	87.2 ± 2.7 (85.8–88.6)	86.7 ± 1.9 (85.4–88.0)	0.2, Small	92.0 ± 1.8 (91.1–93.0)	90.2 ± 2.0 (89.0–91.3)	0.9, Moderate	96.6 ± 2.6 (95.2–98.1)	94.1 ± 2.2 (92.9–95.3)	1.1, Moderate	98.1 ± 1.6 (97.2–98.9)	96.9 ± 2.1 (95.5–98.3)	0.6, Small
CV (%)	1.9	1.7		3.1	2.2		2.0	2.2		2.7	2.3		1.6	2.2	

Under (U); Coefficient of variance (CV); Effect size (ES); Estimated adult stature attainment (EASA); Change of direction (5-0-5 test).
Effect size thresholds: trivial = <0.20; small = >0.21–0.60; moderate = >0.61–1.20; large = >1.21–2.00; very large = >2.01.

Q4 = 14.9%). Specifically, this means that there were four times more players born in the first quarter compared with the last quarter. Second, examining the aggregated age groupings (i.e., U7–U8 and U9–U10), again, a RAE was present compared with the population norm distributions (Q1 = 44.4 and 36.8%; Q4 = 5.6 and 10.5%) except for the U11–U12 group (Q1 = 35.7%; Q4 = 18.6%). The latter finding can be explained by the smaller sample size of the youngest age groups that was $< 50\%$ of the other groups. With respect to the newly proposed reallocation method, the midway point was used between the chronological and ED birth dates that were calculated using the normative growth curves of a study examining secular changes in biological maturation in Belgian boys of the same age categories (Roelants et al., 2009). Before reallocation, the mean differences in player stature and body mass were 24.0 cm and 20.1 kg, respectively. After reallocation, these differences were reduced to 12.4 cm and 18.2 kg, respectively, possibly due to players being more closely matched to stage of biological maturity. With the use of this new method, for almost half (53%; $n = 161$) of the players, a reallocation to another team was not recommended. Specifically, 47% ($n = 141$) of the players in the current selection system are reallocated to a different age category. Of this group of movers, 1% would be reallocated two age categories lower, 21% one age category lower, 23% one age category higher, and 2% two age categories higher. As a result, their skills to compete with their counterparts will be enhanced due to the fact that the variance in stature/body mass has been decreased within the reallocation group. This demonstrates that reallocation method is easy to implement from a practical point of view, given that the total number of players in each category remains almost the same. Obviously, we need to consider other issues that are linked to moving players to a category higher or lower, for instance, social (e.g., friends playing in a different team) or psychological (i.e., youth players with a different cognitive compared with physical maturation). This might be the case if athletes are dropped to "younger" age groups. Proper communication between the coaching staff, the player, and his/her parents with respect to the importance of this reallocation for appropriate long-term player development is certainly recommended.

Phase II: Assessment of the Within-Group Variation of Somatic and Physical Fitness Characteristics Using Chronological and Estimated Developmental Birth Dates

As well as being cost-efficient and easy to apply, the present study (phase II) also provides promising evidence to suggest that the newly proposed player (re)allocation method is seemingly an appropriate strategy for reducing transient, maturity-related anthropometric (physical fitness to a lesser extent) characteristics, which are often afforded to early maturing players, who can also be relatively older (Carling et al., 2009; Towlson et al., 2017). This is evidenced by 75% of the observed between-method comparisons showing that the reallocation method reduced group CV, which was consistent for anthropometric and maturation status characteristics for all of the sampled age categories. This is of relevance and importance for soccer practitioners given that maturity and relative age selection bias can contribute to the premature deselection and playing position allocation of academy soccer players (Towlson et al., 2017), which ultimately confounds the (de)selection processes of talent development centers across the world and likely limits the size of the talent pool for clubs and nations to select from. Therefore, this study provides persuasive early evidence for the application of a new player allocation method to remove the temporary, physical fitness, and anthropometric advantages afforded to older (and sometimes more mature) players.

Limitations of the Newly Proposed Reallocation Model

Despite demonstrating early promise, the newly proposed reallocation method is not without limitations. For instance, the ED birth date for the reallocation method was calculated using the growth curves, which are based on a study published in 2004 or 16 years ago (Roelants et al., 2009). The idea of generic, worldwide normative growth curves has been addressed upon request of the World Health Organization (Beunen et al., 2006), but not realized yet. Therefore, the curves used in this study as a reference point are perhaps limited and only contain growth data of Belgian children and adolescents. More recent (longitudinal) data may have a slightly different impact on the estimations. The second discussion point is that this study considered a specific target group of academy soccer players. In contrast, the growth curves were based on a broader population of mixed ethnicity. This issue could be solved by creating specific growth curves for youth players, eventually even per sport.

Also, despite the fact that academy soccer practitioners suggest that players' physical, maturity, and relative age characteristics are not considered during players' talent selection (Towlson et al., 2019), temporary maturity-related enhancements in anthropometric and physical fitness characteristics seemingly remain to be a consistent discriminatory factor for players who are (de)selected for talent programs (Lovell et al., 2015) and indeed allocated certain playing positions (Deprez et al., 2015; Towlson et al., 2017). Given this constant (sub)conscious maturity-related selection bias, it is important to acknowledge that although the present study has shown that the between-group variation in maturation status does reduce within the reallocation groupings, it is unknown whether reallocated players will mature at a rate that is consistent with that of their new peers.

Future Directions for Research

Although the present study sampled players from two professional soccer academies, which created a combined dataset of 302 academy soccer players for the initial player reallocation (phase I), we acknowledge that further investigations using our newly proposed player allocation method are required to better understand the efficacy of our method to reduce temporary, maturity-related differences between players. Therefore, practitioners and governing bodies should take a coordinated approach to player development research and work collaboratively to aggregate players' relative age, maturity,

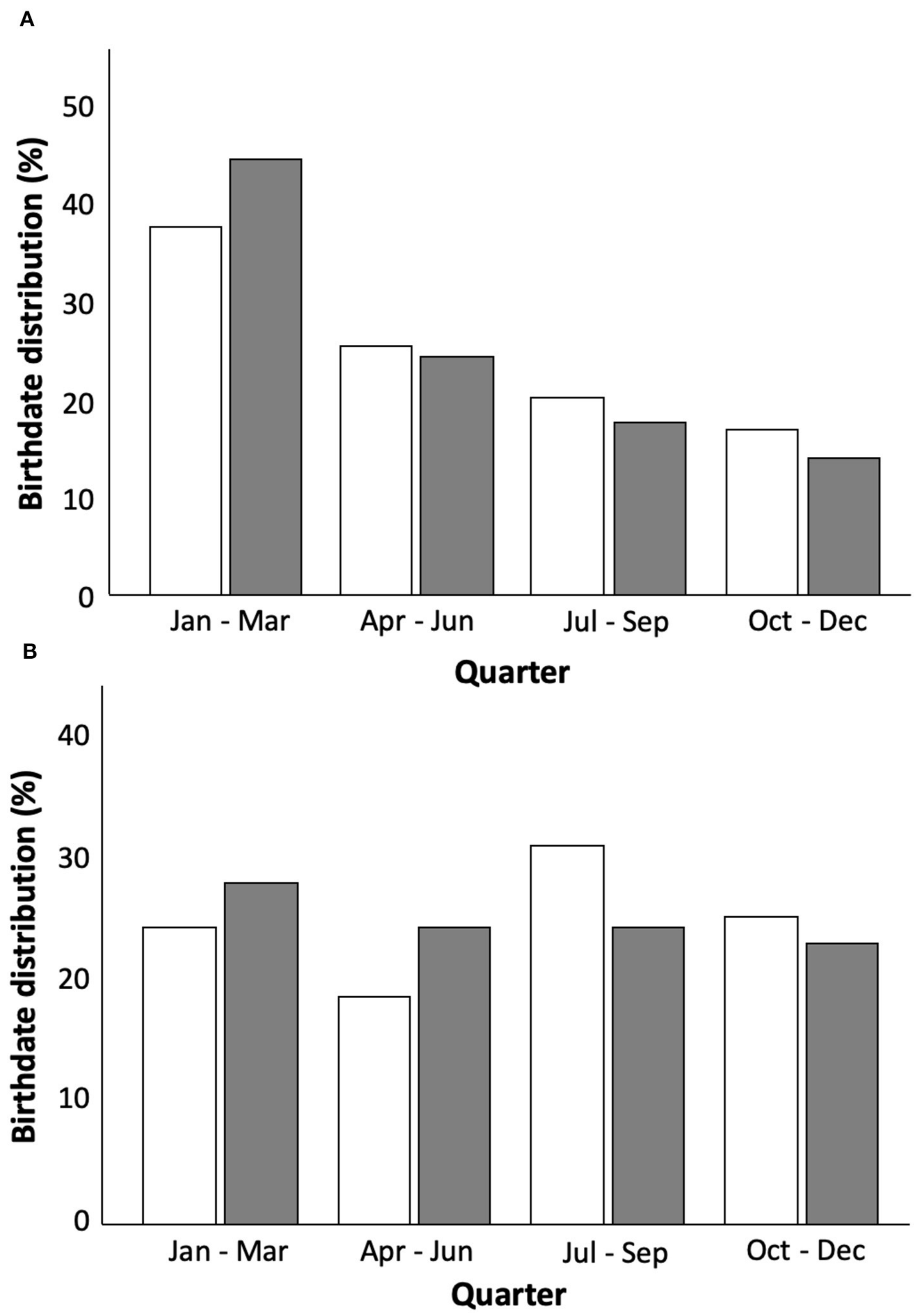

FIGURE 4 | Birthdate distribution of 302 Belgian academy soccer players in percentage per quarter for team X (white bars) and team Y (gray bars), before **(A)** and after reallocation **(B)**.

physical fitness, and anthropometric datasets in order to truly understand the impact of both relative age and maturity selection bias and to offer insight on the effectiveness of new approaches to remove such selection bias. Finally, in this newly proposed reallocation method, we used the midway point between the chronological and ED birth dates. It may be considered to give more weight to either the chronological or developmental birth date, although we now contend the midway point as more intuitive for coaches and practitioners. As well, we only considered physical maturation, while cognitive maturation may also play a role in the reallocation process of youth players, as psychological factors are considered a priority by practitioners during the talent selection process (Towlson et al., 2019). Finally, this study provides a one-time snapshot of RAE across ages at one point in time. It cannot address the insidious effects that RAE has inevitably had on athlete success and or dropout leading

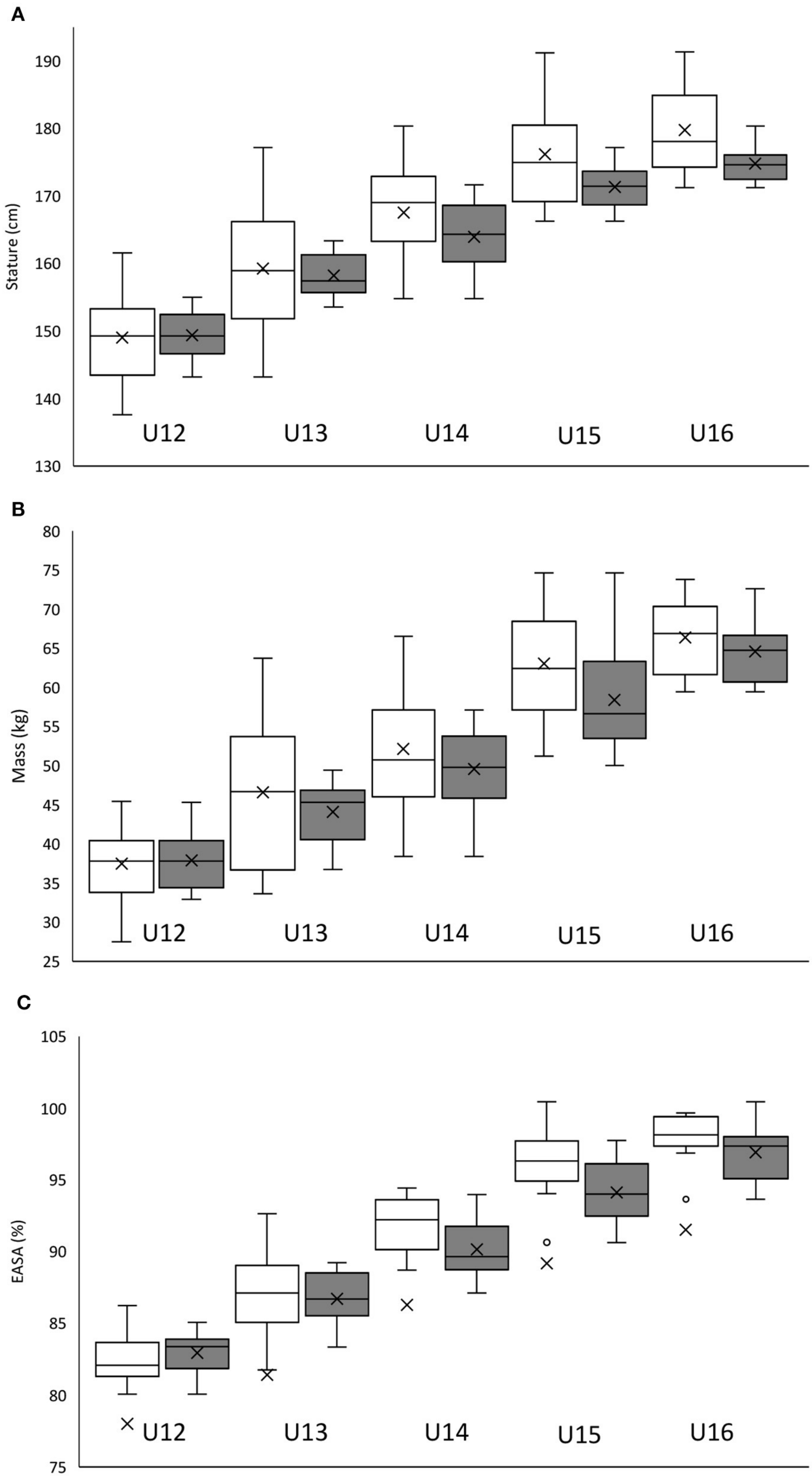

FIGURE 5 | The mean ± SD (95% CI) for anthropometric (**A**: stature; **B**: mass; **C**: estimated percentage of final adult stature attainment) characteristics of 80 UK academy soccer players according to traditional chronologically ordered (white bars) vs. the proposed reallocation method (gray bars).

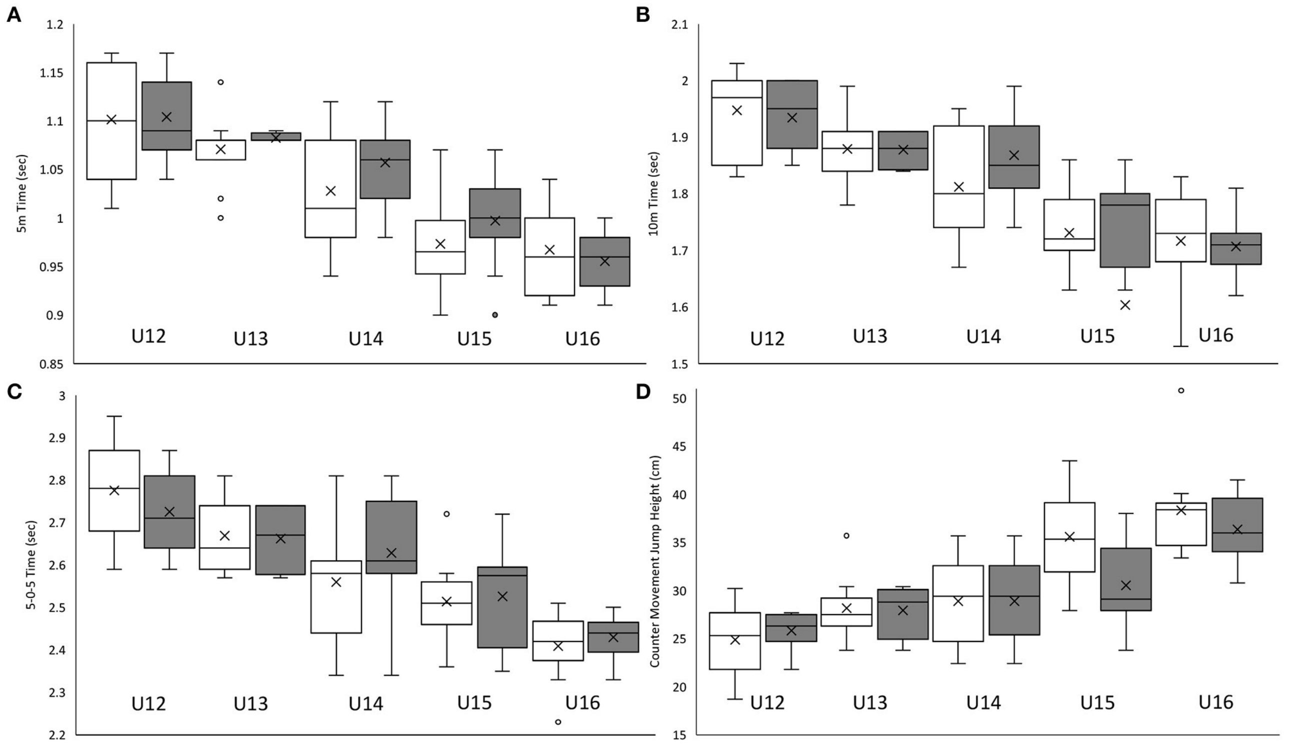

FIGURE 6 | The mean ± SD (95% CI) for physical (**A**: 5 m acceleration time; **B**: 10 m acceleration time; **C**: 5-0-5 time; **D**: counter movement jump height) characteristics of 80 UK academy soccer players according to traditional chronologically ordered (white bars) vs. the proposed reallocation method (gray bars).

up to this moment in time, or how RAE may have differentially affected different age groups prior.

Although in its infancy, this new player allocation method shows early promise to reduce the over-representation of players born within a particular quartile (i.e., quartiles 1 and 2). As well, the findings of the present study suggest that birth date distribution would become more evenly spread and age differences reduced within the newly formed allocation grouping. Generally speaking, the younger player of one category will likely be the smallest (or one of the smallest), and the oldest player is likely the tallest (or one of the tallest). In fact, this is a particular benefit of using the median point between chronological and ED birth dates, given that if a player does not show a stature corresponding to his age, his ED birth date will compensate for this (**Figure 6**). Therefore, being the oldest player may not provide a physical advantage to this player, as is the case in the current selection procedure. In return, however, older players gain a cognitive advantage, which is not considered in the actual selection system today.

Immediate Practical Implications

Regarding implementation, the best period to measure may be the end of the season in order to give clubs proper time to compose the youth categories for the next season. Along the same lines, we consider one measurement per season during growth spurt appropriate in order to avoid a reorganization in-season. Finally, we do not consider this reallocation as a disadvantage for technical or tactical periodization if players are moved up or down. The first priority is the long-term player development, and tactical skills can also be taught at a later stage.

There may be particular implications for athletes being dropped to "younger" age groups and potentially being "re-shuffled" the subsequent years. This may impact their social relationships, as they are no longer competing in the same team as their friends or schoolmates. Despite the prospect of later-developing athletes being recategorized to participate in "younger" chronologically ordered age groups, "bio-banded" athletes have reported that they enjoyed and understood the purpose of the format, while feeling that there was less chance of sustaining injury (Cumming et al., 2018). Also, recategorized athletes have also reported that development-based categorization methods provided more opportunity for them to engage key psychological constructs (Cumming et al., 2018), deemed important when assessing talent (Towlson et al., 2019). In addition, parents of recategorized athletes have stated that they trusted coaches to do what is right for their child's development and that such methods would not be adopted if the staff did not believe there was any value in doing so (Reeves et al., 2018). Apart from physical development, there may also be other reasons to reallocate players to a younger age group such as cognitive maturity that cannot be captured with this new method. In some countries, there is indeed a similar "medical dispensation" procedure to reallocate players to a younger age group because of neurological issues such as attention deficit hyperactivity disorder (ADHD) or autism spectrum disorders. In any case, proper communication between the coaching staff, the player, and his/her parents with respect to the importance of this reallocation for appropriate long-term player development is certainly recommended.

There are also practical considerations (and directions) for sports governing bodies looking to adopt this method. Rather than leaving the initiative to individual clubs, it is much more appropriate to look for a structural solution that is implemented by the national governing bodies for a given level of competition where teams are involved in (e.g., all age categories in elite youth soccer).

CONCLUSION

In summary, in this study, an innovative and evidence-based allocation method that is easy to implement was proposed and tested (given few personnel and little funding is required). With the use of a dataset of 302 academy soccer players, the results first of all showed that this new allocation method can level the playing field with respect to stature and body mass differences and also result in a more even distribution of birth dates throughout a selection year. In fact, while a clear RAE was found for the overall sample of youth players before reallocation, it completely disappeared after reallocation. Second, the examination of 80 UK academy soccer players also confirmed that reallocating players based upon development age reduced significantly the within-playing group variation of both somatic and physical fitness characteristics. The reduction in relative age- and maturity-related bias will lead to fewer dropouts and thus a larger player pool, which could benefit, in turn, talent detection, selection, and development. Put differently, this new method allows the retention of as many youth players as possible, for as long as possible, in the best learning environment possible.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Informed assent and parental consent were acquired for each player prior to testing and a detailed protocol (MP013675) was approved by the Research Ethics Committee UZ/KU Leuven, Belgium. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

WH initiated the research from the very beginning, transferred this idea to an online application that can be used by national associations, and clubs considering to reallocate their youth players to a higher or a lower team that is more in line with their physical development. CT was also involved from the start and contributed to all stages of the study. He was assisted by CM, in particular for the statistics and the processing of the UK data. JS and MT revised preliminary drafts of the paper as well as the final version. SV contributed to the study as it was part of hismaster's thesis. GO is a practitioner who is involved in the relative age and late maturity effects for many years, launched the idea for calculation of the developmental age as highlighted in the study (inverse use of growth curves), and contributed to the customized excel sheet that was used to produce an automatic developmental age calculator.

REFERENCES

Abbott, W., Williams, S., Brickley, G., and Smeeton, N. J. (2019). Effects of bio-banding upon physical and technical performance during soccer competition: a preliminary analysis. *J. Sports* 7:193. doi: 10.3390/sports7080193

Barnsley, R., Thompson, A., and Barnsley, P. (1985). Hockey success and birthdate: the RAE. *Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Barnsley, R. H., and Thompson, A. H. (1988). Birthdate and success in minor hockey: the key to the NHL. *Can. J. Behav. Sci.* 20, 167–176. doi: 10.1037/h0079927

Beunen, G. P., Rogol, A. D., and Malina, R. M. (2006). Indicators of biological maturation and secular changes in biological maturation. *Food Nutr. Bull.* 27, 244–256. doi: 10.1177/15648265060274S508

Boucher, J., and Halliwell, W. (1991). The Novem system: a practical solution to age grouping. *Can. Assoc. Health Phys. Educ. Recreat.* 57, 16–20.

Carling, C., Le Gall, F., Reilly, T., and Williams, A. M. (2009). Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players? *Scand. J. Med. Sci. Sports* 19, 3–9. doi: 10.1111/j.1600-0838.2008.00867.x

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med. (Auckland, N.Z.)*, 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cohen, J. (1988). *Statistical Power Analysis for the Behavioural Sciences*. Hillsdale, NJ: Erlbaum.

Cumming, S. P., Brown, D. J., Mitchell, S., et al. (2018). Premier League academy soccer players' experience of competing in a tournament bio-banded for biological maturation. *J. Sports Sci.* 36, 757–765. doi: 10.1080/02640414.2017.1340656

Cumming, S. P., Lloyd, R. S., Oliver, J. L., Eisenmann, J. C., and Malina, R. M. (2017). Bio-banding in sport: applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength Cond. J.* 39, 34–47. doi: 10.1519/SSC.0000000000000281

Deprez, D., Fransen, J., Boone, J., Lenoir, M., Philippaerts, R., and Vaeyens, R. (2015). Characteristics of high-level youth soccer players: variation by playing position. *J. Sports Sci.* 33, 243–254. doi: 10.1080/02640414.2014.934707

Draper, J. A. (1985). The 505 test: a test for agility in horizontal plane. *Aust. J. Sci. Med. port*, 17, 15–18.

Epstein, L. H., Valoski, A. M., Kalarchian, M. A., and McCurley, J. (1995). Do children lose and maintain weight easier than adults: a comparison of child and parent weight changes from six months to ten years. *Obes. Res.* 3, 411–417. doi: 10.1002/j.1550-8528.1995.tb00170.x

Ford, P., De Ste Croix, M., Lloyd, R., Meyers, R., Moosavi, M., Oliver, J., et al. (2011). The long-term athlete development model: physiological evidence and application. *J. Sports Sci.* 29, 389–402. doi: 10.1080/02640414.2010.536849

Grondin, S., Deschaies, P., and Nault, L. (1984). Trimesters of birth and school output. *Apprent. Soc.* 16, 169–174.

Helsen, W., and Starkes, J. (2020). "Relative age effects in youth and elite sport: what have we learned after 20 years of research?" in *Relative Age Effects in Sport: International Perspectives,* eds J. C. Dixon, S. Horton, L. Chittle, and J. Baker (New York, NY: Taylor and Francis), 98–116. doi: 10.4324/9781003030737-9

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., van Winckel, J., and Williams, A. M. (2012). The relative age effect in European professional soccer: Did ten years of research make any difference? *J. Sports Sci.* 30, 1665–1671. doi: 10.1080/02640414.2012.721929

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *Am. J. Hum. Biol.* 10, 791–798. doi: 10.1002/(SICI)1520-6300(1998)10:6<791::AID-AJHB10>3.0.CO;2-1

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (2000). Effect of a change in selection year on success in male soccer players. *Am. J. Hum. Biol.* 12, 729–735. doi: 10.1002/1520-6300(200011/12)12:6<729::AID-AJHB2>3.0.CO;2-7

Helsen, W. F., Van Winckel, J., and Williams, A. M. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Hopkins, W. G., Marshall, S. W., Batterham, A. M., and Hanin J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.* 41, 3–13. doi: 10.1249/MSS.0b013e31818cb278

Hurley, W., Lior, D., and Tracze, S. (2001). A proposal to reduce the age discrimination in canadian minor hockey. *Can. Public Policy* 27, 65–75. doi: 10.2307/3552374

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in english lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS ONE*, 10:e0137238. doi: 10.1371/journal.pone.0137238

Malina, R. M., Bouchard, C., and Bar-Or, O. (2004). *Growth, Maturation, and Physical Activity*. Champaign, IL: Human Kinetics. doi: 10.5040/9781492596837

Malina, R. M., Chamorro, M., Serratosa, L., and Morate, F. (2007). TW3 and Fels skeletal ages in elite youth soccer players. *Ann. Hum. Biol.* 34, 265–272. doi: 10.1080/03014460701207601

Mann, D. L., and van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci.* 35, 784–790. doi: 10.1080/02640414.2016.1189588

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development : a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Musch, J., and Hay, R. (1999). The relative age effect in soccer: cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Soc. Sport J.* 16, 54–64. doi: 10.1123/ssj.16.1.54

Nolan, J. E., and Howell, G. (2010). Hockey success and birth date: the relative age effect revisited. *Int. Rev. Sociol Sport* 45, 507–512. doi: 10.1177/1012690210371560

Philippaerts, R. M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., et al. (2006). The relationship between peak stature velocity and physical performance in youth soccer players. *J. Sports Sci.* 24, 221–230. doi: 10.1080/02640410500189371

Reeves, M. J., Enright, K. J., Dowling, J., and Roberts, S. J. (2018). Stakeholders'understanding and perceptions of bio-banding in junior-elite football training. *Soccer Soc.* 19, 1166–1182. doi: 10.1080/14660970.2018.1432384

Roberts, S. J., McRobert, A. P., Rudd, J., Enright, K., and Reeves, M. J. (2020). Research in another un-examined (RAE) context. A chronology of 35 years of relative age effect research in soccer: is it time to move on? *Sci. Med. Football.* doi: 10.1080/24733938.2020.1841278

Roelants, M., Hauspie, R., and Hoppenbrouwers, K. (2009). References for growth and pubertal development from birth to 21 years in Flanders, Belgium, *Ann. Hum. Biol.* 36, 680–694. doi: 10.3109/03014460903049074

Romann, M., Lüdin, D., and Born, D.-P. (2020). Bio-banding in junior soccer players: a pilot study. *BMC Res. Notes* 13:240. doi: 10.1186/s13104-020-05083-5

Schorer, J., Wattie, N., and Baker, J. (2013). A new dimension to relative age effects: constant year effects in German youth handball. *PLoS ONE* 8:23632227. doi: 10.1371/annotation/346754d7-87e5-4e5f-90c8-86a23632227a

Steingröver, C., Wattie, N., Baker, J., Helsen, W. F., and Schorer, J. (2017a). The interaction between constituent year and within-1-year effects in elite German youth basketball. *Scand. J. Med. Sci. Sports* 27, 627–633. doi: 10.1111/sms.12672

Steingröver, C., Wattie, N., Baker, J., Helsen, W. F., and Schorer, J. (2017b). Geographical variations in the interaction of relative age effects in youth and adult elite soccer. *Front. Psychol.* 8, 1–13. doi: 10.3389/fpsyg.2017.00278

Tanner, R., and Gore, C. (2012). *Physiological Tests for Elite Athletes*. Champaign, IL: Human Kinetics.

Towlson, C., Cobley, S., Midgley, A. W., Garrett, A., Parkin, G., and Lovell, R. (2017). Relative age, maturation and physical biases on position allocation in elite-youth soccer. *Int. J. Sports Med.* 38, 201–209. doi: 10.1055/s-0042-119029

Towlson, C., Cobley, S., Parkin, G., and Lovell, R. (2018). When does the influence of maturation on anthropometric and physical fitness characteristics increase and subside? *Scand. J. Med. Sci. Sports* 28, 1946–1955. doi: 10.1111/sms.13198

Towlson, C., Cope, E., Perry, J. L., Court, D., and Levett, N. (2019). Practitioners' multi-disciplinary perspectives of soccer talent according to phase of development and playing position. *Int. J. Sports Sci. Coach.* 14, 528–540. doi: 10.1177/1747954119845061

Towlson, C., MacMaster, C., Gonçalves, B., Sampaio, J., Toner, J., MacFarlane, N., et al. (2020a). The effect of bio-banding on physical and psychological indicators of talent identification in academy soccer players. *Sci. Med. Football*. Ahead of print. doi: 10.1080/24733938.2020.1862419

Towlson, C., Salter, J., Ade, J. D., Enright, K., Harper, L. D., Page, R. M., et al. (2020b). Maturity-associated considerations for training load, injury risk, and physical performance in youth soccer: one size does not fit all. *J. Sport Health Sci.* 19, S2095-2546(20)30119-8. doi: 10.1016/j.jshs.2020.09.003

Verhulst, J. (1992). Seasonal birth distribution of west European soccer players: a possible explanation. *Med. Hypoth.* 38, 346–348. doi: 10.1016/0306-9877(92)90030-G

Yagüe, J. M., Izquierdo, J. M., and Muñoz, Á. (2020). The relative effect of age in international football: Europe Vs South America. *European Journal of Human Movement*, 44, 34–49. doi: 10.21134/eurjhm.44.539

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Relative Age Effect in Canadian Hockey: Prevalence, Perceived Competence and Performance

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The term "relative age effect" (RAE) is used to describe a bias in which participation in sports (and other fields) is higher among people who were born at the beginning of the relevant selection period than would be expected from the distribution of births. In sports, RAEs may affect the psychological experience of players as well as their performance. This article presents 2 studies. Study 1 aims to verify the prevalence of RAEs in minor hockey and test its associations with players' physical self-concept and attitudes toward physical activities in general. Study 2 verifies the prevalence of the RAE and analyzes the performance of Canadian junior elite players as a function of their birth quartile. In study 1, the sample is drawn from 404 minor hockey players who have evolved from a recreational to an elite level. Physical self-concept and attitudes toward different kinds of physical activities were assessed via questionnaires. Results showed that the RAE is prevalent in minor hockey at all competition levels. Minor differences in favor of Q1-born players were observed regarding physical self-concept, but not attitudes. In study 2, data analyses were conducted from the 2018–2019 Canadian Hockey League database. Birth quartiles were compared on different components of performance by using quantile regression on each variable. Results revealed that RAEs are prevalent in the CHL, with Q1 players tending to outperform Q4 players in games played and power-play points. No other significant differences were observed regarding anthropometric measures and other performance outcomes. RAEs are still prevalent in Canadian hockey. Building up perceived competence and providing game-time exposure are examples of aspects that need to be addressed when trying to minimize RAEs in ice hockey.

Keywords: relative age effect, ice hockey, perceived competence, minor hockey, junior hockey, attitudes, performance

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INTRODUCTION

The term "relative age effect" (RAE) is used to describe a bias, evident in the upper echelons of youth sports, where participation is higher among those born at the beginning of the relevant selection period—and, therefore, lower among those born at the end of the selection period—than would be expected from the standard distribution of live births (Larouche et al., 2010). In general, in the literature on the RAE, live birth distributions are analyzed in the form of quartiles (Q) in which birth months are grouped in four 3-month categories (Q1: January 1st–March 31st; Q2: April 1st–June 30th; Q3: July 1st–September 30th; Q4: October 1st–December 31st). Past research has shown that the RAE is predominantly found in many sports (Grondin et al., 1984; Turnnidge et al., 2014). This effect is mainly found in sports in which physicality prevails—such as soccer, rugby, and ice hockey (Lames et al., 2008; Till et al., 2010; Helsen et al., 2012)—and among male athletes (Romann et al., 2018). Ice hockey is a typical example where the RAE seems to be highly prevalent among male players (Barnsley et al., 1985; Wattie et al., 2007; Nolan and Howell, 2010) and female Canadian (Weir et al., 2010; Hancock, 2017), Czech (Bozděch and Zháněl, 2020), and Swedish players (Stenling and Holmström, 2014). Recently, an analysis of the 2017 International Ice Hockey Federation (IIHF) Championships showed that the RAE was prevalent mostly among goaltenders and forwards (Bozděch and Zháněl, 2019). RAEs were also found among Russian hockey players, who evolve in hockey academies and the *Kontinental Hockey League* (Bezuglov et al., 2020). In the province of Quebec (Canada), RAEs were also found at the minor hockey level, where the effects remained even after changes in cutoff dates for each age-group category were implemented (Lavoie et al., 2015).

Theoretically, RAEs are the result of multiple interactions involving individual, task-related, and environmental factors (Wattie et al., 2015). More specifically, this means that the development of RAEs will depend on variables such as participants' age (individual), the popularity of the sport (environmental), and multiple facets related to the sport itself (skills, positions). In Canada, ice hockey is one of the most popular sports, if not the most popular. In that sense, RAEs seem likely to occur. According to Hancock et al. (2013b), RAEs are developed through social interactions that involve 3 types of social agents: the players themselves (children and adolescents), coaches, and parents (in the case of minor hockey). Such interactions have the potential to influence social agents' perceptions about the players (and the perceptions of the players themselves), which could affect (either positively or negatively) the participation of children and adolescents in organized sports. From this perspective, if the RAE can considerably affect players in team selection at different levels, it might also be associated with psychosocial outcomes that would tend to favor early-born players (Q1, Q2). For example, the team selection process closely contributes to these RAEs. Early-born players are frequently perceived as more talented by coaches and are prioritized at the moment of player selection. Scouts, coaches, and parents are somewhat more impressed by these "more dominant" players, which leads to favorable outcomes for these players. Such attention toward their performances may reinforce early-born players' sense of accomplishment, which consequently can enhance their level of confidence in sports. These athletes will feel confident about their hockey abilities and competencies. In parallel, interactions involving players with coaches and parents have the potential to make the experience of a hockey player's progression a more enjoyable experience (e.g., the hockey experience is more fun). Inversely, late-born (e.g., Q3 and Q4) players, who are more likely to be rejected from teams early in their "hockey career," live the opposite scenario: coaches will perceive them as not strong enough, or "not ready for the next level." Indeed, late-born players may feel that they are losing the opportunity to play at a higher competition level, which can potentially hinder their sense of accomplishment and make their hockey experience less enjoyable. Consequently, in front of what could appear as a "wasted" season, late-born players may decide to stop practicing their sport earlier in the process. RAEs were also demonstrated in education, where early-born primary school girls (Sprietsma, 2010) and adolescents (Cobley et al., 2009) tended to get enrolled in higher-performing academic programs and to obtain higher scores in different subject areas. RAEs were also reported in physical education classes, with higher motor skills among early-born pupils (Gadžić et al., 2017). Fenzel (1992) also showed that early-born students had higher self-esteem and tended to perform better in school. In sports, RAE research showed that early-born players get more exposure and are frequently perceived as more talented or physically "gifted" than their younger counterparts (e.g., late-born players; Hancock et al., 2013b). From this perspective, such exposure, and the interactions that result from this, should affect on psychological outcomes such as self-esteem (Fenzel, 1992) and perceived sport competence (Guillet et al., 2002). As shown by Kawata et al. (2017), early-born players (e.g., Q1) might gain psychosocial benefits such as increased enjoyment and more favorable attitudes toward physical activity. On the other hand, such an uneven way of selecting young athletes may have negative consequences on their desire to pursue their athletic careers (Musch and Grondin, 2001). By reducing their chances to access elite status, young athletes may become discouraged, eventually leading to sports attrition (Musch and Hay, 1999; Vaeyens et al., 2005). It is reasonable to posit that late-born players must have a less enjoyable hockey experience. Despite the contribution of past research to understanding the mechanisms underlying RAEs in sports (Baker and Logan, 2007; Baker et al., 2010), no recent data are available regarding RAEs among minor hockey players in Canada, a country counting more than 600,000 registered players in organized hockey (Hockey Canada, 2019).

The RAE may also exert its influence on different aspects of performance. Despite the early advantages that RAE affords players in multiple facets, some authors suggest the possibility of a reversal of RAEs on a longer-term basis (Gibbs et al., 2012). Reversal of RAEs is defined as a period in which late-born players (Q4) tend to catch up with, or even outperform, early-born players at higher levels of competition. Two hypotheses could explain the reversal of the RAE in sports. The first hypothesis is psychological, which stipulates that younger players tend to develop a better capacity to adapt by getting the opportunity to develop psychological attributes such as increased motivation, resilience, and capacity to overcome challenges. This psychologically related hypothesis was tested in elite soccer (Ashworth and Heyndels, 2007) and should also apply in the context of ice hockey. Like professional soccer, the pathways toward elite or professional hockey are paved with many obstacles that can be overcome with a high degree of resilience, motivation, and determination. A good example of the importance of such factors comes from Herbison et al. (2019), who underlined the importance of considering competitiveness, passion, and confidence as factors associated with the capacity to overcome obstacles among undrafted NHL players. Under such circumstances, late-born players who evolved in positive and favorable environments are potentially less affected by RAEs, which means that their social environments (coaches, parents, and teammates) may interact favorably toward the development of these psychological assets. In complementarity to this first hypothesis, the biological–athletic reversal effect occurs among those who have the genetic and athletic background that predisposes young athletes for excellence (Ashworth and Heyndels, 2007; McCarthy et al., 2016). Support for the biological–athletic hypothesis was obtained at the National Hockey League (NHL) level. A study published by Fumarco et al. (2017) showed that despite being drafted later, late-born players (Q4) tend to be more productive and durable than players who were preferred in the past due to their birth date (Fumarco et al., 2017). However, no study has yet to allocate specific attention to the moment of occurrence of this pattern. In this regard, it is relevant to try to shed light on a possible fading of the RAEs by verifying if it occurs at a younger level such as the Canadian elite junior level.

Objectives of the Study

This article includes two studies related to the RAE in Canadian hockey. In study 1, the focus is on a sample of young (12–17 years old) minor hockey players, and the aim is to verify a RAE on outcome variables such as attitudes toward sport and perceived competence in hockey. The study also verifies whether the RAE differs according to the playing levels of young players. For study 1, our hypotheses are based on previous research and on the potential impacts of RAEs, suggesting that early-born players (Q1–Q2) should display more favorable-positive attitudes toward sport and should show a higher level of perceived competence in the physical self, compared to late-born players. Taking into account various other factors such as age groups and competition level (on the distribution of births and psychosocial outcomes) should make it possible to further analyze how RAEs influence players throughout their hockey progression as a player.

Study 2 aims to verify the prevalence of the RAE and its relationships with performance indicators in the Canadian Hockey League (CHL), which regroups the best junior players in the country. Our first hypothesis for study 2 is based on recent ice hockey research (Nolan and Howell, 2010; Bezuglov et al., 2020) and posits that even 35 years after the results from Barnsley et al. (1985) and Grondin et al. (1984) with players from the CHL, RAEs persist. A second objective of study 2 is to determine whether RAEs translate into different levels of performance in Canada's top junior league. A lack of significant differences (in performance outcomes) between players born in the different quartiles would suggest a possible reversal (or fading) of RAEs at the CHL level, which would be in line with the results of Fumarco et al. (2017).

STUDY 1: PREVALENCE AND PSYCHOSOCIAL OUTCOMES IN MINOR HOCKEY

Sample

The sample in study 1 consists of 404 young hockey players aged between 12 and 17 (15.4 ± 1.9 years). All players were registered with Quebec's provincial federation and came from 3 different age groups based on the provincial federation's categorization guidelines: U13-Peewee (11–12 years old: $n = 95$), U15-Bantam (13–14 years old: $n = 63$), and U17-Midget (15–17 years old: $n = 246$). Players also came from two competition levels [competitive/elite ($n = 202$; 50%) and recreational ($n = 202$; 50%)]. Competitive level players are registered in the *Ligue de Hockey d'Excellence du Québec* (LHEQ) and play the AA and BB levels. These players represent their region and generally have a higher training volume (2–3 training sessions per week) and more demanding schedules (35–50 games per year). Recreational level players are those who play at the community level (house league); they train less often (e.g., once a week) and play fewer games (25–40 a year). We used a convenience sample and tried to replicate the proportions of participants at each level of competition in Quebec. The project was approved beforehand by the ethics committee of the lead researchers' academic institution (CER-17-240-08-01.10) and by the provincial hockey federation (Hockey Québec). We implemented 2 data collection protocols. First, we conducted an initial data collection during the teams' meetings following one of their training sessions. Fifteen teams at the competitive/elite level, of which nine agreed to take part in the study, were randomly selected on the Hockey Québec website. We then contacted coaches by phone to obtain their permission to meet and inform their players about the research. For participants under 14 years old, a parental written consent was required. Once the coaches agreed to participate, the research team handed out questionnaires to the participant, who was previously placed in a quiet room to ensure their concentration. For the second protocol, we collected data directly during hockey tournaments. To this end, we obtained tournament directors' endorsement a few weeks beforehand. The research team approached 5 tournament directors and three accepted to take part in the study. Subsequently, we asked the randomly selected teams' coaches for permission to meet and inform their players about the project and to distribute the questionnaires. To avoid interfering with the tournaments and to ensure the players' full concentration, they had permission to take the weekend to fill out the questionnaires.

Measures

Data came from a questionnaire used in a study designed to investigate the environment of adolescent hockey players, which included environmental and psychosocial variables [for a detailed description of the questionnaire, see Huard Pelletier et al. (2020)]. This questionnaire includes environmental factors such as accessibility and opportunities for sport, social factors related with coaches and parents, and two psychosocial constructs: attitudes and physical self-concept. In the present study, the first part of the questionnaire assessed some sociodemographic variables and birth date. Each birth date was coded into birth quartiles (Q1 to Q4) by referring to the usual categorization that is used in each league: (1) Q1: January–February–March, (2) Q2: April–May–June, (3) Q3: July–August–September, and (4) Q4: October–November–December. For the second part of the questionnaire, we used two specific psychosocial outcomes, namely, attitudes toward sport and exercise (hockey, sport, weight training, and aerobic exercises) and physical self-concept measures (physical self-concept, perceived sport competence, perceived endurance, and perceived strength).

Attitudes toward sport and other exercise behaviors were measured using a 12-item semantic scale. We measured attitudes toward two categories of behaviors: (1) hockey-sport (ice hockey: 3 items; leisure-time sports: 3 items) and (2) exercise behaviors (strength training: 3 items; cardiovascular exercises: 3 items). We asked participants to rate their level of agreement on a six-point scale (low score = negative attitude, high score = positive attitude) by completing the following sentence: "For me, [playing ice hockey] is [useless-useful, unpleasant-pleasant, demotivating-motivating]." Preliminary analyses showed satisfactory reliability for each subscale, with excellent McDonald's omega coefficients ($\omega_{\text{Hockey}} = 0.89$, $\omega_{\text{sports}} = 0.88$, $\omega_{\text{strength}} = 0.94$, $\omega_{\text{cardio}} = 0.89$). From each subscale, we calculated two composite scores for attitudes.

Physical self-concept was measured with the Physical Self-Description Questionnaire (PSDQ: Ninot et al., 2000). Thus, 3 dimensions (subscales) of physical self-perception were measured, using 12 items: perceived sport competence (4 items), perceived cardiovascular endurance (4 items), and perceived physical strength (4 items); each subscale was conceived as a six-point Likert scale (from 1 = unfavorable perceived competence to 6 = high perceived competence). We also calculated a global self-concept score by using all 12 items. Preliminary analyses show a very good reliability for each subscale ($\omega_{\text{Sport}} = 0.87$, $\omega_{\text{Strength}} = 0.85$, $\omega_{\text{Endurance}} = 0.83$, $\omega_{\text{global}} = 0.79$). Then, we used the 3 subscales, plus a composite score (mean score calculated from the 12 items), for a global measure of physical self-concept.

Statistical Analyses

We verified for the prevalence of RAE by conducting cross-tabulations (chi-square statistic) on players' birth quartile distribution. To prevent bias in the distribution of birth quartiles, we followed the recommendations of Delorme and Champely (2015) and compared the birth rate of Québec in 2004 (the vast majority of players of the sample were born in Quebec), which corresponds to the median age of our sample (provincial birth rates: Statistique Canada, 2018). In line with Delorme and Champely (2015), we also tested each age category with its previous group, to confirm if birth distributions differ from one category to another. This resulted in 3 group comparisons: U13 vs. U15, U15 vs. U18, and U13 vs. U18. Significant differences at this level would mean that RAEs would affect sport participation regarding age groups. For the second part of our analyses (psychosocial outcomes), we conducted nonparametric group comparisons to compare birth quartiles regarding attitudes and physical self-concept scores and to evaluate if early-born players (Q1 and Q2) displayed more favorable attitudes toward physical activities and a stronger physical self-concept. We used the Kruskal–Wallis H and the test on median scores to test for significant group differences.

Results

RAE Among Quebec's Minor Hockey

Table 1 shows that birth distribution differs regarding birth quartiles and is significantly different from the numbers obtained from the national survey (Statistique Canada, 2018), with players from Q3 and Q4 representing only 41% of the total sample ($\chi^2 = 12;593$, $p < 0.01$). Therefore, our data showed that RAE is prevalent in minor hockey in Quebec.

Age Group, Playing Level, and Category

Results showed that, for age groups (**Table 2**), birth quartile repartition is similar across age groups ($\chi^2 = 4.42$, $p = 0.62$; Cramer's $V = 0.08$, $p = 0.62$). When we compared each age category with the previous one, these differences remained non-significant (all $p > 0.25$). Similarly, no RAEs related with playing level were observed ($\chi^2 = 1.82$, $p = 0.61$; Cramer's $V = 0.07$, $p = 0.69$), suggesting that despite the observed disproportion of births in quartiles, the magnitude of the RAEs in the different playing levels remains essentially the same.

RAE on Psychosocial Outcomes Among Minor Hockey Players

Table 3 shows descriptive statistics on attitude scores and measures of self-concept for each birth quartile. Results from **Table 3** indicate that there are no significant differences between quartiles due to a RAE for attitudes toward sports and hockey ($H = 4.51$, $p = 0.21$) and attitudes toward exercise behaviors ($H = 0.80$, $p = 0.85$). Most participants showed strong and favorable attitudes toward physical activities, and these attitudes are similar in the different quartiles. No significant RAEs were observed on attitudes regarding age groups and playing level (all $p > 0.30$).

For the physical self-concept measures, RAEs were observed in general self-concept, with Q3-born players displaying lower scores than players born in Q1 ($H = 9.085$, $p = 0.028$). In other sub-dimensions of physical self-concept, the proportions of Q1-born players tend to be higher than that of Q3- and Q4-born players, but these differences were not significant. When we verified for RAEs specific to age, no significant differences were observed. However, we observed some significant differences that support RAEs at the competitive level. For global physical self-concept, Q1 and Q2 players showed higher scores than those of Q3 and Q4 ($H = 9.863$, $p = 0.020$). Similar results were observed for perceived strength ($H = 8.162$, $p = 0.043$), and perceived sport competence tends to be higher among Q1 and Q2 players ($H = 7.011$, $p = 0.072$). In summary, there is a RAE in minor hockey, especially among competitive players. Birth quartile does not appear to cause disparities in attitudes toward physical activities but has an impact on general self-concept, perceived sport competence, and perceived strength.

Discussion for Study 1

Results from study 1 confirm that the RAE is prevalent in Quebec's minor hockey. This is similar to Baker et al.'s (2010) study that showed that RAEs are prevalent in minor ice hockey. Interestingly, despite the prevalence of RAEs, they do not seem to be specific to an age group or a playing level. This result is also in line with Grondin et al. (1984), who showed that RAEs applied to all minor hockey age groups, from Atom (9 and 10 years old) to Midget (15 and 16 years old). However, in our data, there was no difference regarding birth distribution, which means that RAEs prevail from U13 to U18. However, our data do not allow us to confirm or discard the idea that birth distributions differ in each cohort. Using longitudinal data (each category of birth distribution) would be most relevant for testing whether RAEs fluctuate among specific cohorts and for testing whether sports attrition, which tends to begin at adolescence, is related to the RAE (Delorme et al., 2011). In addition to a possible attrition among older players, our younger participants were only 12 and 13 years old. At this age, boys have not quite reached the peak of puberty, which usually occurs 1 to 2 years later (Marshall and Tanner, 1970; Williams and Currie, 2000). The physical benefits associated with puberty (increase in strength, size, and power, among others) that may accentuate the bias that favors early-born players may not be maximized at this stage of their development, which may have reduced RAEs among different age groups (Musch and Grondin, 2001). In this regard, anthropometric measures and an assessment of the pubertal stage reached would be useful in future studies.

Results regarding psychosocial outcomes showed partial support for RAEs in minor ice hockey. First, we observed no significant results regarding attitudes toward hockey, sports, and exercise behaviors. From this perspective, our results showed

TABLE 1 | Birth quartiles in minor hockey compared with 2004 live births (Statistics Canada).

Birth quartile	*N* [Standardized residuals]	%	Birth quartiles—Quebec 2004 [standardized residuals]	χ^2
Q1	123 [23.5]	30.4	24%	
Q2	110 [10.5]	27.2	25%	12.593*
Q3	85 [−14.5]	21.0	26%	
Q4	80 [−19.5]	19.8	24%	$W = 0.178$
Missing	6	1.5	N/A	
Total	404	100%	N/A	

*$p < 0.01$.

TABLE 2 | RAE prevalence across age groups and playing levels.

Birth quartile	Age groups *N* (%) [Standardized residuals]			χ^2	Playing level *N* (%) [Standardized residuals]		χ^2
	U13	U15	U18		Recreational	Competitive	
Q1	39 (31%) [7.5]	39 (31%) [7.3]	44 (31%) [8.3]	4.42^{ns}	64 (33%) [15.8]	58 (29%) [7.8]	1.82^{ns}
Q2	28 (22%) [−3.5]	40 (32%) [8.3]	41 (28%) [5.3]	$W = 0.11$	49 (25%) [−0.2]	61 (30%) [10.8]	$W = 0.07$
Q3	29 (23%) [−2.5]	23 (18%) [−8.7]	33 (21%) [−2.7]		44 (22%) [−5.2]	41 (20%) [−9.2]	
Q4	30 (24%) [−1.5]	25 (19%) [−6.7]	25 (20%) [−10.7]		39 (20%) [−10.2]	41 (20%) [−9.2]	

ns, non significant.

TABLE 3 | Comparisons of birth quartiles regarding physical self-concept and attitudes toward physical activities.

	Median (Md)	Q1	Q2	Q3	Q4
Attitudes toward hockey and sports	5.75	5.47 ± 0.72	5.61 ± 0.43	5.48 ± 0.65	5.58 ± 0.59
N > Md (%)	N/A	49 (41%)	50 (45%)	34 (40%)	30 (38%)
Attitudes toward exercise	4.75	4.67 ± 1.00	4.60 ± 0.98	4.51 ± 1.18	5.53 ± 1.04
N > Md (%)	N/A	60 (50%)	53 (48%)	43 (50%)	39 (51%)
Physical self-concept	4.42	4.59 ± 1.14	4.38 ± 0.62	4.28 ± 1.04*	4.58 ± 1.47
N > Md (%)	N/A	66 (67%)	60 (55%)	29 (35%)	37 (47%)
Perceived sport competence	5.00	4.94 ± 0.95	5.01 ± 0.78	4.67 ± 0.92**	4.81 ± 0.95
N > Md (%)	N/A	53 (48%)	54 (49%)	28 (33%)	34 (45%)
Perceived strength	4.25	4.38 ± 1.42	4.13 ± 1.09	3.92 ± 1.04***	4.05 ± 1.09
N > Md (%)	N/A	58 (49%)	53 (48%)	27 (33%)	30 (39%)
Perceived endurance	4.33	4.27 ± 0.95	4.27 ± 0.75	4.06 ± 0.99	4.20 ± 1.17
N > Md (%)	N/A	47 (39%)	33 (30%)	22 (27%)	28 (37%)

*Q3 < Q1: $H = 9.085$, $p = 0.028$.
** Q3 < Q1: $H = 7.196$, $p = 0.066$.
***Q3, Q4 < Q1: $H = 7.117$, $p = 0.068$.
N > Md: proportion of participants (%) who reported a score higher than the median score.

that RAEs do not affect young hockey players' attitudes toward their sport and other kinds of physical activities, even when considering age group and playing level. However, we have to be cautious in our interpretation because it cannot be excluded that this absence of impact of the RAE on players' attitudes is caused by the strong and favorable attitudes toward ice hockey (e.g., a possible ceiling effect). In fact, players who had a negative attitude toward ice hockey may have already given up on the sport, as sport dropouts sometimes occur even before the beginning of adolescence.

Results regarding physical self-concept measures showed some interesting differences. Such results are somewhat congruent with past RAE research, albeit with quite small effect sizes and with slightly younger participants (Thompson et al., 2004; Kawata et al., 2017). In terms of measures of physical self-concept, our results showed a tendency in which Q3 players tend to show lower scores, but not Q4. In fact, in each measure of physical self-concept, Q4 players showed similar scores to those of Q1 players. Moreover, our results showed that RAEs were also significant according to the level of competition in which players evolve. Results from our study suggest that RAEs seemed to be present among competitive players on measures of physical self-concept (global), perceived sport competence, and perceived strength. This would mean that early-born players showed stronger perceptions of their physical competencies. Such small differences can be explained by several hypotheses. First, there is a possibility that players build their self-perceptions mostly by comparing themselves almost exclusively with teammates and opponents (Marsh, 1987), and, assuming that the player selection process is rigorous at the beginning of the season, there should be no major differences in participants' perceived competence over a season. A study focusing on young ice hockey players' experience showed that RAEs are indeed present, but that there are no significant differences in terms of minutes played or physical interactions with opponents between those born earlier and later in the year (Baker et al., 2010). In this regard, Baker concludes that it makes sense that players from the same team tend to develop similar perceptions of competence since they are similar in their physical stature and in their level of play, and have faced the same level of competition over a season. Even if we do not have anthropometrical data, our results suggest that, despite the presence of a RAEs, adolescent hockey players have very similar psychosocial attributes regardless of their birth quartile and level of play, with the noteworthy exception of perceived sport competence in the most competitive levels. Having equivalent self-concept scores between Q1 and Q4 players is congruent with the psychological hypothesis that suggests that late-born players develop strong psychological attributes to survive sports selection (Ashworth and Heyndels, 2007). Furthermore, it is possible that using a global sport competence physical self-concept subscale instead of a hockey-specific physical self-concept subscale has reduced the precision of competence assessment and, therefore, has underestimated the RAE on physical self-concept. While this point is beyond the scope of this study, it is relevant to point out that developing a hockey-specific perceived competence scale might help refine and identify key differences that could be related to players' hockey experience. Such a specific scale was developed by Forsman et al. (2016); they successfully created and validated a soccer-specific competence scale.

STUDY 2: PREVALENCE AND PERFORMANCE IN THE CHL

Sample

In study 2, we assessed the prevalence of the RAE in junior hockey and compared players born in the four different quartiles on multiple performance indicators.

Data were extracted from raw data files pick224.com[1] This website provides databases extracted from official CHL game box scores and includes performance metrics that are not available on the CHL website. We selected players who participated in 2018–2019 in the CHL, which combines the 3 major junior leagues: Western Hockey League (WHL), Ontario Hockey League (OHL), and Quebec Junior Major Hockey League (QJMHL). The CHL is identified as the predominant league, providing over 32% of NHL players (Canadian Hockey League, 2019). Total sample consists of 1318 players distributed almost equally across leagues (WHL: $n = 478$; OHL: $n = 433$; QJMHL: $n = 407$). Mean age ($\pm$ SD) was also similar across leagues (OHL = 18.31 $\pm$ 1.24 years; WHL = 18.3 $\pm$ 1.21 years; QJMHL = 18.43 $\pm$ 1.16 years).

Measures

Birth quartile was calculated from raw data that were available in each database. For both studies, each birth date was coded into birth quartiles (Q1 to Q4), the same quartiles as the ones used in study 1. Body weight and height were used to verify if early-born players differ from late-born players. Based on past research in this field (Grondin and Trudeau, 1991), we expected no major differences on players' anthropometric profiles.

Performance outcomes were assessed using metrics that were available in the data files. In the junior sample, we assessed players' performance with 4 performance metrics: (1) games played (n), (2) total points, (3) 5-on-5 points (goals + assists), and (4) power-play points. Such indicators were used in past research (Wattie et al., 2007) and are commonly used to reflect a player's utilization and his offensive contribution to his team.

Statistical Analyses

We tested for the presence of RAEs by conducting cross-tabulation analyses and calculating chi-square (χ^2) scores for the entire CHL sample. Same analyses were conducted with each league separately. In a way similar to that of study 1, we tested the distribution of births in quartiles using expected values from the 2001 distribution of births in Canada (median birth year; Statistique Canada, 2018). Secondly, we compared players' age and anthropometric data (height and weight) across birth quartiles by conducting one-way ANOVAs, with the Bonferroni correction for *post-hoc* analyses. To evaluate RAEs on performance indicators, we used quantile regressions to verify if RAEs tend to diminish on multiple performance indicators that were available in the CHL database. Compared to OLS

[1]Data extracted from the website https://pick224.com.

regression, quantile regression is more flexible to non-normal data distributions (Hao and Naiman, 2007). Quantile regression is also used to compare subsamples and prevent selection bias that may be caused by an arbitrary smaller sample (Lê Cook and Manning, 2013). Regression analyses were conducted on the 25th, 50th, 75th, and 90th percentiles of each distribution. This technique was performed in the past to verify differences among NHL players' number of games played and total points (Fumarco et al., 2017). RAEs would be maintained if early-born players still performed better than the late-born players (at the 75th and 90th percentile). However, results from the Fumarco et al. (2017) study make it more difficult to confirm if a reversal of the RAE really prevails, especially because players' age varies more substantially at this level. From this perspective, it becomes most relevant to verify whether the same kind of pattern occurs at a younger age. In this regard, a stabilization of the RAE would occur if no significant differences in performance were observed (no significant regression coefficient in the 75th and 90th percentile), and a reversal of the RAE would occur when the performance of late-born players was better than that of early-born players.

Results

Prevalence of RAEs in the CHL

Table 4 shows birth distribution across the three CHL leagues. Results suggest that the RAE is prevalent in the CHL, and more specifically in all three of the CHL leagues ($\chi^2 > 85.00$, $p < 0.001$), with significant deviations from Canada birth distribution for the year 2001. Effect sizes for each league were moderate to large ($W > 0.45$), suggesting a high level of disproportion between birth quartiles. We must specify that players from other nationalities (e.g., Europe, USA) are eligible to play in the CHL. A total of 232 CHL players (OHL = 41%; QJMHL = 28%; WHL = 31%) came from outside Canada, which represents 17% of the total sample. When considering players' birth country, RAEs remained significant, with a medium effect size ($\chi^2 = 19.96$, $p < 0.001$, $W = 0.30$)[2]

Morphological Differences in the CHL

Results from anthropometric data, reported in **Table 5**, showed no significant differences regarding height and weight ($F_{\text{height}} = 0.472$, $p = 0.702$; $F_{\text{weight}} = 0.368$, $p = 0.776$), even if Q4 players tend to be taller. Such results mean that players who evolve in the CHL have similar morphological attributes at this stage of development.

RAEs and Performance Indicators

RAEs prevail for powerplay contribution (PP-pts) and the number of games played. Scores from regression analyses showed performance levels at the upper quartiles, which is associated with the best level of performance across each birth quartile. As shown in **Table 6**, analyses were conducted for the 75th and 90th percentiles. The most important RAEs were observed at percentile 90, which represents CHL's most performing players. For instance, Q1 and Q2 displayed more points than Q4 players, and Q2 outperformed Q4 players in powerplay points.

[2]Significant RAEs were observed in QJMHL, but not in the OHL and WHL. Further analyses regarding rules governing the draft of European and American players are needed.

Discussion for Study 2

Study 2 shows that RAEs in major junior Canadian hockey prevails across the country, as has been the case for more than 60 years (Wattie et al., 2007). RAEs have not declined at the major junior level (CHL), leading us to believe that early-born players are still prioritized in player selection in ice hockey. Such results are in line with those of Barnsley et al. (1985), obtained more than 35 years ago with OHL and WHL players. More recently, Nolan and Howell (2010) "revisited" RAEs in the CHL and showed that the Canadian hockey culture has not changed over the decades. Our results suggest that the ways to assess talent or potential have remained the same over time. From this perspective, such results are in line with Hancock's model (Hancock et al., 2013a), in which coaches and scouts are social agents who influence talent detection and team selection; consequently, they help maintain RAEs in elite hockey. Interestingly, our results showed that similar RAE patterns seem to prevail among non-Canadian players, who came into the CHL wishing to get more exposure and to increase their chances to be drafted in the NHL.

From a players' physical stature standpoint, we think the attributed value of having a strong physical stature remains important, which is in line with what was demonstrated by many authors. In fact, players' morphology has increased over the last 50 years (taller, heavier, stronger), which suggests an advantage for early-born players at younger levels (Montgomery, 2006; Quinney et al., 2008). The CHL showed no differences regarding stature of players regarding birth quartile, which is in line with past research on this topic (Grondin and Trudeau, 1991). Therefore, this suggests that late-born players who "survived" the selection process at the major junior level are possibly those who are more mature physically, despite their birth month (early developers). In addition, as the body size of NHL players seems to have plateaued over the last decade (Wendorf, 2015), the prototype of the small, fast, and skilled players has emerged in the mid-2010s NHL (Larkin, 2019). Professional hockey can be thought of as a "copycat league," in which contenders tend to imitate the Stanley Cup champions' "recipe" for success. In this regard, we might, at first glance, find this recent shift of paradigm encouraging for late-born players who do not have the same "physical" advantage as their "older" teammates. However, this rejoicing might well be short-lived, as we are seeing a return to the norm of "big and fast" prototype players among recent Stanley Cup champions (Larkin, 2019), which gives an advantage to early-borns.

The second part of study 2 focused on performance outcomes. This issue recently raised some interest by proposing the hypothesis of a reversal of the RAE at later stages of athletic development (Gibbs et al., 2012). Such a hypothesis is plausible given that players who survive the unfavorable years may develop more resilience, character, and abilities, which serve them to perform better in the future. One such hypothesis was supported in other sports (McCarthy et al., 2016) and among established NHL players (Fumarco et al., 2017) by showing that late-born players performed at least as well as early-born players who were prioritized previously at the entry draft. Results from study 2 are partially consistent with the hypothesis of a reversal of RAEs at the CHL level. Our results showed that despite the fact that early-born players receive more exposure (e.g., games played, points),

TABLE 4 | Distribution of births in each quartile in the Canadian hockey league (CHL).

Birth quartile	Total *N* (%) [Standardized residuals]	WHL *N* (%)	OHL *N* (%)	QJMHL *N* (%)	Birth quartiles in Canada 2001
Q1	553 (41.6%) [218.5]	203 (42.5%) [83.5]	177 (40.9%) [68.8]	168 (41.3%) [66.3]	24%
Q2	383 (28.7%) [48.5]	130 (27.2%) [10.5]	126 (29.1%) [17.8]	122 (30.0%) [20.3]	26%
Q3	237 (18.5%) [−85.5]	89 (18.6%) [−30.5]	87 (20.1%) [−21.2]	68 (16.7%) [−33.7]	26%
Q4	145 (11.2%) [−181.5]	56 (11.7%) [−63.5]	43 (9.9%) [−65.2]	49 (12.0%) [−52.7]	24%
Total	1 318	478	433	407	N/A
χ^2	274.194*	100.795*	90.076*	85.708*	N/A
Cohen's *W*	0.469	0.459	0.456	0.459	N/A

*$p < 0.001$.

TABLE 5 | Anthropometric measures of CHL players as a function of birth quartile.

		Birth quartile			
Measures	**Total**	**Q1**	**Q2**	**Q3**	**Q4**
Height (cm)	181.3 ± 10.54	181.1 ± 10.81	181.5 ± 10.11	180.8 ± 10.71	182.0 ± 10.4
Weight (kg)	83.75 ± 7.23	83.79 ± 7.29	83.76 ± 7.17	84.14 ± 7.37	83.75 ± 7.23

TABLE 6 | Birth quartile and performance in the CHL: Results from quantile regression.

Outcome		Birth quartile (with 95% Confidence Intervals)			
	Constant	**Q1**	**Q2**	**Q3**	**Q4**
GP75	64 (62.94–65.06)	66* (0.81–3.19)	66* (0.75–3.25)	66* (0.66–3.34)	64 (n/a)
GP90	68 (67.46–68.54)	68 (−0.61–0.61)	68 (−0.64–0.64)	68 (−0.69–0.69)	68 (n/a)
Pts75	38 (30.25–45.75)	40 (−6.37–10.74)	40 (−7.14–11.15)	42 (−5.83–13.83)	38 (n/a)
Pts90	52 (41.69–62.31)	62** (−1.61–21.61)	64** (−0.16–24.16)	63 (−2.06–24.06)	52 (n/a)
5 vs. 5 Pts75	28 (11.58–14.41)	28 (−0.69–2.68)	27 (−0.73–2.73)	31*** (−0.83–2.83)	28 (n/a)
5 vs. 5 Pts90	36 (20.14–23.86)	42 (−0.21–4.21)	41 (−1.29–3.29)	45* (−0.42–4.42)	36 (n/a)
PPpts 75	6 (3.53–8.47)	8 (−0.78–4.78)	8 (−0.91–4.91)	11*** (−0.13–6.13)	6 (n/a)
PPpts 90	12 (8.75–15.25)	15 (−0.67–6.67)	16*** (0.16–7.84)	15 (−1.13–7.13)	12 (n/a)

*Games Played (GP): $Q1_{75}$-$Q2_{75} > Q4_{75}$, $p < 0.01$.
**5 vs. 5 pts: $Q1_{90} > Q4_{90}$; $Q1_{90}$ $Q2_{90} > Q4_{90}$, $p < 0.10$.
***PP Pts: $Q3_{75} > Q4_{75}$, $p = 0.10$; $Q1_{90} > Q4_{90}$, $p < 0.05$; $Q2_{90} > Q4_{90}$, $p < 0.05$; $Q3_{90} > Q4_{90}$, $p = 0.10$.

they do not perform substantially better than late-born players on a more global estimate of performance (e.g., total points and 5 vs. 5 points). This suggests a possible shift toward a reversal of RAEs at the major junior level.

Despite such observations, our analyses of the performance outcomes have their limitations. In study 2, we considered indicators related to playing time, offensive production, and puck possession. Many other indicators could have been considered and deserve more attention for future research. For instance, future studies should include additional indicators of players' performance (e.g., face offs, turnovers, shooting %, etc.). Such approaches are now more feasible with the emergence of artificial intelligence-based applications. In a more practical way, it would benefit major junior organizations' stakeholders (scouting staff, coaches, etc.) to be aware of the results of study 2. Late-born players have the potential to catch up at a later stage of their development. Consequently, stakeholders should consider ways to continue talent evaluation on a longer-term basis or could simply begin the evaluation process at a later stage (e.g., after 16 years old). This approach would be better adapted to long-term athlete development and sports expertise models (Balyi and Way, 2005).

GENERAL DISCUSSION

Results from the first part of this study shows that although the RAE in Canadian ice hockey has been identified almost 40 years ago, there is still a disproportionally high number of early-born players in Canadian hockey. The popularity of the sport combined with specific ice hockey tasks (physicality, skills, and gender) can also explain why RAEs are still strong over the years. However, we think that the policy regarding age categories (24 months per category) is the main reason that explains why RAEs are still prevalent in Canadian hockey. As the Lavoie et al. (2015) study showed, simply changing the cutoff dates had an immediate impact that would favor the "new" early-born players. In this regard, it is relevant to think about new age categories to diminish RAEs and offer equal opportunities for all players, beginning with avoiding 24-month-long categories (Grondin et al., 1984). Comparing the Canadian situation with the organization of minor and junior hockey leagues and talent identification in other countries would be an interesting avenue for future research and would provide further knowledge about the impacts of RAEs in ice hockey.

Study 1 was a first attempt to shed light on the potential psychological impacts of RAE at the minor hockey level. Beyond the simple analysis of prevalence, the present study set out to verify to what extent RAEs can affect different ice hockey players' experiences. According to study 1, RAEs do not seem to affect the enjoyment of playing ice hockey, but it has an impact on the development of physical self-perception, especially among the most competitive players. As Hancock's (2013) social agents model stipulates, decision makers, coaches, parents, and athletes themselves need to be informed and concerted about RAEs, in order to better understand the developmental aspects of hockey players, from the beginning to the end of an athletic "pathway."

The second part of our study demonstrates that RAEs also prevail at the elite junior level in Canada, and possibly in other countries. As Wattie et al. (2015) suggest, a complex interaction involving the multiple facets of the game, combined with environmental factors, make the RAE a real concern, even at such high levels of competition. Interestingly, our analyses also demonstrated that there are RAEs among non-Canadian CHL players. Such results are congruent with those obtained with Czech (Bozděch and Zháněl, 2019) and Russian players (Bezuglov et al., 2020). Additional research should be conducted among CHL stakeholders (coaches, scouts, and managers), who are in charge of talent detection and recruitment. Such research would refine our understanding of the RAE occurrence at the elite level and could provide additional insights that would help to diminish discrimination against late-born players, some of whom are forgotten on the pathway toward elite hockey. The analyses of performance indicators showed that despite being less represented, late-born players have performances comparable to those of early-born players, suggesting a potential reversal of the RAE. These results highlight the need to further examine the outcomes on the players themselves, but also by taking more into account the perceptions of coaches, scouts, and agents on the criteria they use when observing the most promising talents in ice hockey.

CONCLUSION AND FUTURE DIRECTIONS

This study provides an updated overview of the RAE in the field of Canadian ice hockey. Despite being a subject that has generated scientific interest over the last 40 years, the RAE is still a predominant phenomenon in Canada's national sport. In summary, despite the presence of RAEs in the sport, late-born players who have gotten through the selection process seem to have similar psychosocial (in minor hockey) and morphological (in major junior) profiles. Educating coaches and raising awareness about RAEs in sports is still necessary to prevent sports dropout and provide equal opportunities for players to manifest their talent at different levels. Decision makers should also think about offering late-born players more exposure opportunities, namely, by playing against (or with) early-born players or by introducing them to different kinds of events (showcases, testing sessions, etc.). Despite its contribution to better understanding RAEs, this study has its limitations and suggests interesting research avenues for the future. Longitudinal designs that include players' anthropometric measures would give a better estimate of how the RAE phenomenon takes place in the early stages of sports development (e.g., 12 years old). A more in-depth scrutinization of coaches' and scouts' perspectives about RAEs and talent would also help to understand how it could be approached in a long-term perspective. Finally, cooperation and dialogue with sport federations would certainly help to identify key actions that would allow young athletes to continue to develop not only as athletes but also as healthy individuals.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by CER-17-240-08-01.10. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JL supervised redaction of the manuscript. He was involved in relation (Study 1 and Study 2), statistical analyses and literature review. VH was mostly involved in the literature review process, writing the manuscript (Study 1 and general discussion) and took part to statistical analyses (Study 1). FT was involved in redaction (discussions, S1, S2 and general), and provide expertise in the problem statement. SG participated in manuscript redaction (problem statement, discussion, analyses) and provide additional background (literature review) in the theoretical background of both studies. All authors confirm having participated to the preparation of this manuscript.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Ashworth, J., and Heyndels, B. (2007). Selection bias and peer effects in team sports: the effect of age grouping on earnings of German soccer players. *J. Sport Econ.* 8, 355–377. doi: 10.1177/1527002506287695

Baker, J., Cobley, S., Montelpare, W. J., Wattie, N., and Faught, B. E. (2010). Exploring proposed mechanisms of the relative age effect in Canadian minor hockey. *Int. J. Sport Psychol.* 41, 148–159.

Baker, J., and Logan, A. J. (2007). Developmental contexts and sporting success: birth date and birthplace effects in national hockey league draftees 2000–2005. *Br. J. Sport Med.* 41, 515–517. doi: 10.1136/bjsm.2006.033977

Balyi, I., and Way, R. (2005). *The Role of Monitoring Growth in Long-Term Athlete Development*. Canada Sport for Life. Retrieved at: www.sportforlife.ca

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *Can. Assoc. Health Phys. Educ. Rec.* 51, 23–28.

Bezuglov, E., Shvets, E., Lyubushkina, A., Lazarev, A., Valova, Y., Zholinsky, A., et al. (2020). Relative age effect in Russian elite hockey. *J. Strength Cond. Res.* 34, 2522–2527. doi: 10.1519/JSC.0000000000003687

Bozděch, M., and Zháněl, J. (2019). Effect of relative age in men's ice hockey: the analysis of playing positions, hand dominance, and the level of basic anthropometric characteristics at the ice hockey world championships 2017. *J. Phys. Educ. Sport* 19, 2429–2434. doi: 10.7752/jpes.2019.04368

Bozděch, M., and Zháněl, J. (2020). The influence of the relative age effect in the czech youth ice hockey league. *Montenegrin J. Sports Sci. Med.* 9, 27–33. doi: 10.26773/mjssm.200905

Canadian Hockey League. (2019). *71 CHL Players Selected in 2019 NHL Draft*. Canadian Hockey League. Available online at: https://chl.ca/article/71-chl-players-selected-in-2019-nhl-draft

Cobley, S., McKenna, J., Baker, J., and Wattie, N. (2009). How pervasive are relative age effects in secondary school education? *J Educ Psychol.* 101, 520–528. doi: 10.1037/a0013845

Delorme, N., Chalabaev, A., and Raspaud, M. (2011). Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand. J. Med. Sci. Sport* 21, 120–128. doi: 10.1111/j.1600-0838.2009.01060.x

Delorme, N., and Champely, S. (2015). Relative age effect and chi-squared statistics. *Int. Rev. Soc. Sport* 50, 740–746. doi: 10.1177/1012690213493104

Fenzel, L. M. (1992). The effect of relative age on self-esteem, role strain, GPA, and anxiety. *J. Early Adolesc.* 12, 253–266. doi: 10.1177/0272431692012003002

Forsman, H., Gråstén, A., Blomqvist, M., Davids, K., Liukkonen, J., and Konttinen, N. (2016). Development and validation of the perceived game-specific soccer competence scale. *J. Sports Sci.* 34, 1319–1327. doi: 10.1080/02640414.2015.1125518

Fumarco, L., Gibbs, B. G., Jarvis, J. A., and Rossi, G. (2017). The relative age effect reversal among the National Hockey League elite. *PLoS ONE* 12:e0182827. doi: 10.1371/journal.pone.0182827

Gadžić, A., Milojević, A., Stanković, V., and Vučković, I. (2017). Relative age effects on motor performance of seventh-grade pupils. *Eur. Phys. Educ. Rev.* 23, 534–542. doi: 10.1177/1356336X16671696

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. *Int. Rev. Soc. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Grondin, S., Deshaies, P., and Nault, L.-P. (1984). Trimestre de naissance et participation au hockey et au volleyball. *La Rev. Québéc. De l'activ. Phys.* 2, 97–103. Available online at: https://www.perception.psy.ulaval.ca/sites/perception.psy.ulaval.ca/files/ctools/grondin_deshaies_and_nault_1984_-_english_version.pdf

Grondin, S., and Trudeau, F. (1991). Date de naissance et ligue nationale de hockey: analyses en fonction de différents paramètres. *Rev. Sci. Tech. Act. Phys. Sport* 26, 37–45.

Guillet, E., Sarrazin, P., Carpenter, P. J., Trouilloud, D., and Cury, F. (2002). Predicting persistence or withdrawal in female handballers with social exchange theory. *Int. J. Psychol.* 37, 92–104. doi: 10.1080/00207590143000243

Hancock, D. J. (2017). Female relative age effects and the second-quartile phenomenon in young female ice hockey players. *Psychol. Sport Exer.* 32, 12–16. doi: 10.1016/j.psychsport.2017.05.002

Hancock, D. J., Adler, A. L., and Coté, J. (2013a). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Hancock, D. J., Ste-Marie, D. M., and Young, B. W. (2013b). Coach selections and the relative age effect in male youth ice hockey. *Res. Q. Exerc. Sport* 84, 126–130. doi: 10.1080/02701367.2013.762325

Hao, L., and Naiman, D. Q. (2007). *Quantile Regression (No. 149)*. London: SAGE. doi: 10.4135/9781412985550

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., Van Winckel, J., and Williams, A. M. (2012). The relative age effect in European professional soccer: did ten years of research make any difference? *J. Sports Sci.* 30, 1665–1671. doi: 10.1080/02640414.2012.721929

Herbison, J. D., Martin, L. J., and Sarkar, M. (2019). Achievement despite adversity: a qualitative investigation of undrafted national hockey league players. *Sport Psychol.* 33, 285–294. doi: 10.1123/tsp.2018-0037

Hockey Canada. (2019). *Hockey Canada's Annual Report, 2018-2019*. Retrieved at: https://cdn.agilitycms.com/hockey-canada/Corporate/About/Downloads/2018-19-hockey-canada-annual-report-e.pdf

Huard Pelletier, V., Girard, S., and Lemoyne, J. (2020). Adolescent hockey players' predispositions to adopt sport and exercise behaviours: an ecological perspective. *PLoS ONE* 15:e0228352. doi: 10.1371/journal.pone.0228352

Kawata, Y., Kamimura, A., Oki, K., Yamada, K., and Hirosawa, M. (2017). "Relative age effect on psychological factors related to sports participation among Japanese elementary school children," in *Advances in Human Factors in Sports and Outdoor Recreation*, *Vol. 496,* eds P. Salmon, and A. C. Macquet (Cham: Springer), 199–211. doi: 10.1007/978-3-319-41953-4_18

Lê Cook, B., and Manning, W. G. (2013). Thinking beyond the mean: a practical guide for using quantile regression methods for health services research. *Shanghai Arch. Psych.* 25, 55–59. doi: 10.3969/j.issn.1002-0829.2013.01.011

Lames, M., Augste, C., Dreckmann, C., Görsdorf, K., and Schimanski, M. (2008). Der "relative age effect"(RAE): neue hausaufgaben für den Sport. *Leistungssport* 38, 4–9.

Larkin, M. (2019). *The NHL's Evolution of Post-Season Dominance*. The Hockey News; Roustan Media Publishing. Retrieved at: https://www.si.com/hockey/all-access/malarkey-the-nhls-evolution-of-post-season-dominance

Larouche, R., Laurencelle, L., Grondin, S., and Trudeau, F. (2010). Influence of birth quarter on the rate of physical activities and sports participation. *J. Sports Sci.* 28, 627–631. doi: 10.1080/02640411003587392

Lavoie, F., Laurencelle, L., Grondin, S., and Trudeau, F. (2015). Temporal plasticity of the relative age effect in ice hockey: The case of elite minor players in Québec. *Int. J. Appl. Sports Sci.* 27, 14–25. doi: 10.24985/ijass.2015.27.1.14

Marsh, H. W. (1987). The big-fish-little-pond effect on academic self-concept. *J. Educ. Psychol.* 79, 280–295. doi: 10.1037/0022-0663.79.3.280

Marshall, W. A., and Tanner, J. M. (1970). Variations in the pattern of pubertal changes in boys. *Arch. Dis. Child* 45, 13–23. doi: 10.1136/adc.45.239.13

McCarthy, N., Collins, D., and Court, D. (2016). Start hard, finish better: further evidence for the reversal of the RAE advantage. *J. Sports Sci.* 34, 1461–1465. doi: 10.1080/02640414.2015.1119297

Montgomery, D. L. (2006). Physiological profile of professional hockey players-a longitudinal comparison. *Appl. Physiol. Nutr Met.* 31, 181–185. doi: 10.1139/h06-012

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Musch, J., and Hay, R. (1999). The relative age effect in soccer: cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociol. Sport J.* 16, 54–64. doi: 10.1123/ssj.16.1.54

Ninot, G., Delignières, D., and Fortes, M. (2000). L'évaluation de l'estime de soi dans le domaine corporel. *Rev. Sci. Tech. Act. Phys. Sport* 53, 35–48.

Nolan, J. E., and Howell, G. (2010). Hockey success and birth date: the relative age effect revisited. *Int. Rev. Sociol. Sport* 45, 507–512. doi: 10.1177/1012690210371560

Quinney, H. A., DeWart, R., Game, A., Snydmiller, G., Warburton, D., and Bell, G. (2008). A 26 year physiological description of a national hockey league team. *Appl. Physiol. Nutr. Met.* 33, 753–760. doi: 10.1139/H08-051

Romann, M., Rössler, R., Javet, M., and Faude, O. (2018). Relative age effects in Swiss talent development–a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–2031. doi: 10.1080/02640414.2018.1432964

Sprietsma, M. (2010). Effect of relative age in the first grade of primary school on long-term scholastic results: international comparative evidence using PISA 2003. *Educ. Econ.* 18, 1–32. doi: 10.1080/09645290802201961

Statistique Canada. (2018). *Tableau 13-10-0415-01 Naissances Vivantes, Selon le Mois [Birth Rates, According to Month]*. Retrieved at: https://www150.statcan.gc.ca/t1/tbl1/fr/tv.action?pid=1310041501

Stenling, A., and Holmström, S. (2014). Evidence of relative age effects in Swedish women's ice hockey. *Talent Dev. Excel.* 6, 31–40. Available online at: http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-96790

Thompson, A. H., Barnsley, R. H., and Battle, J. (2004). The relative age effect and the development of self-esteem. *Educ. Res*. 46, 313–320. doi: 10.1080/0013188042000277368

Till, K., Cobley, S., Wattie, N., O'hara, J., Cooke, C., and Chapman, C. (2010). The prevalence, influential factors and mechanisms of relative age effects in UK Rugby League. *Scand. J. Med. Sci. Sports* 20, 320–329. doi: 10.1111/j.1600-0838.2009.00884.x

Turnnidge, J., Hancock, D. J., and Côté, J. (2014). The influence of birth date and place of development on youth sport participation. *Scand. J. Med. Sci. Sports* 24, 461–468. doi: 10.1111/sms.12002

Vaeyens, R., Philippaerts, R. M., and Malina, R. M. (2005). The relative age effect in soccer: A match-related perspective. *J. Sports Sci.* 23, 747–756. doi: 10.1080/02640410400022052

Wattie, N., Baker, J., Cobley, S., and Montelpare, W. J. (2007). A historical examination of relative age effects in Canadian hockey players. *Int. J. Sport Psychol.* 38, 178–186.

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med*. 45, 83–94. doi: 10.1007/s40279-014-0248-9

Weir, P. L., Smith, K. L., Paterson, C., and Horton, S. (2010). Canadian women's ice hockey: evidence of a relative age effect. *Talent Dev. Excel.* 2, 209–217.

Wendorf, B. (2015). *NHL Player Size From 1917-18 to 2014-15: A Brief Look*. Retrived at: https://hockey-graphs.com/2015/02/19/nhl-player-size-from-1917-18-to-2014-15-a-brief-look/ (accessed October, 2020).

Williams, J. M., and Currie, C. (2000). Self-esteem and physical development in early adolescence: pubertal timing and body image. *J. Early Adolesc.* 20, 129–149. doi: 10.1177/0272431600020002002

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ORIGINAL RESEARCH
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Relative Age Effect in 14- to 18-Year-Old Athletes and Their Initial Approach to This Effect—Has Anything Changed Over the Past 10 Years?

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One of the environmental variables associated with early talent development and the achievement of a high level of proficiency in sport is the relative age effect (RAE). The purpose of our study was threefold: (a) to calculate the RAE in young Israeli athletes (ages 14–18 years); (b) to examine how the athletes perceived this effect, if the effect indeed exists; and (c) to compare the RAE findings of this study with those of two previous studies on elite male (Lidor et al., 2010) and female (Lidor et al., 2014) Israeli ballplayers. Participants in the current study were 1,397 athletes (390 females and 1,007 males) who competed in five individual (gymnastics, judo, swimming, tennis, and track and field) and five team (basketball, soccer, team handball, volleyball, and water polo) sports. Data on the RAE, as well as on a number of aspects associated with this effect as perceived by the athletes, were collected *via* two closed questions. Data analyses showed that the RAE was found to be significant among the male athletes in four sports—swimming, basketball, soccer, and team handball; those who were born early in the year had a higher representation in these sport programs. However, this effect was not found to be significant in the female athletes. Most of the female and male athletes did not think that their birth date influenced their athletic success. However, a large portion of those who were born in the first quarter of the year (Q1) and the second quarter of the year (Q2) among the male athletes felt that they exhibited stronger abilities in the sports program compared to their peers who were born in the third and fourth quarters of the year (Q3 and Q4, respectively). The data of the current study provide additional support for the use of an "open door" approach to accepting children to sport programs by policymakers and coaches in Israel.

Keywords: birth date, individual sports, team sports, youth sport programs, sport policy

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INTRODUCTION

The relative age effect (RAE)—one of the environmental variables associated with early talent development and with achieving a high level of proficiency—has been extensively studied in the domain of sport. For example, a recent edited book entitled *Relative Age Effects in Sport—International Perspectives* (Dixon et al., 2020) discusses various aspects related to the effect's contribution to attaining excellence in sport. The term RAE reflects the asymmetrical distribution of athletes based on their birth date relative to an arbitrary cutoff date. For example, athletes who are born soon after a determined cutoff date have a higher representation in elite sport leagues compared to athletes born later (see Barnsley et al., 1985; Côté et al., 2006; MacDonald and Baker, 2013; Hill and Sotiriadou, 2016). Presumably, this effect can be an influence on the recruitment of individuals in sports, as well as on how they develop their athletic abilities/skills.

The RAE implies that individuals who are relatively older than their peers in a given cohort/year, or that their birth date is closer to the cutoff date for their age group classification, are more likely to reach higher athletic achievements (see Thompson et al., 1991; Musch and Grondin, 2001; Côté et al., 2006; Wattie et al., 2008; Schorer et al., 2009; see also Cobley et al., 2009; see Baker et al., 2009; MacDonald and Baker, 2013; Smith et al., 2018, for extensive reviews on the RAE). For example, a number of studies on elite individual and team sports found that athletes who were born early in the competition year had a higher representation than those who were born late in that year (e.g., Baker and Logan, 2007; Schorer et al., 2009). In most studies, two general explanations for the RAE in elite athletes were proposed: (a) the older athletes are more experienced than younger athletes in various motor–physical abilities, such as balance, coordination, speed, and strength, and therefore their performance of these sport skills is enhanced, and (b) the older athletes in their cohort/year are more likely to be selected to better teams and therefore are provided with more advanced guidance and training compared with younger athletes (see, e.g., Cobley et al., 2009; MacDonald and Baker, 2013).

In order to explain conceptually the phenomenon of the RAE, researchers proposed a number of RAE theoretical frameworks. For example, Hancock et al. (2013) discussed three principal social agents that have the potential to influence RAE: parents, coaches, and athletes. In their model, one sociological/psychological theory was proposed for each social agent in order "to explicate the genesis, perpetuation, and amplification of RAEs in sport" (Hancock et al., 2013, p. 631). The three discussed theories were the Matthew effect (social agent: parents), the Pygmalion effect (social agent: coaches), and the Galatea effect (social agent: athletes). The relationships between the three social agents will determine the magnitude of the existence/nonexistence of the RAE. Of particular interest to our study is the Galatea effect (see Merton, 1957) included in the three principal social agents model since the athletes in our study were asked a number of preliminary questions associated with the existence/nonexistence of the RAE.

Wattie et al. (2015), using Newell's (1986) constraints-based model, proposed another RAE theoretical framework. According to Newell, there are three interacting types of constraints responsible for optimal coordination and control of an activity: individual constraints, task constraints, and environmental constraints. Wattie and colleagues associated these three constraints with the RAE and discussed them from a developmental systems theory perspective. They argued that the interrelated associations between the discussed three constraints have the potential to influence the RAE and its appearance/non-appearance in female and male athletes involved in individual and team sports.

However, a number of studies did not find a RAE, namely, that those athletes who were born early in the competition year had a higher representation than those who were born late in that year (e.g., Baker et al., 2009; MacDonald et al., 2009; Barrenetxea-Garcia et al., 2018; Jones et al., 2018). Of particular interest to the objectives of the current study are two studies in which RAE data were collected in elite male and female Israeli ballplayers. In one study (Lidor et al., 2010), the data were collected from 521 male athletes who played basketball ($n = 68$), team handball ($n = 161$), soccer ($n = 209$), and volleyball ($n = 83$) in Division 1 (the highest division of competitive sports in Israel) clubs in Israel. In the second study (Lidor et al., 2014), the RAE data were collected from Israeli female ball players–389 female players playing for various Division 1 ball clubs: 46 basketball players, 107 team handball players, 156 soccer players, and 80 volleyball players. These two studies did not find a significant RAE in these athletes.

Lidor and colleagues proposed two explanations for the lack of RAEs in these elite ballplayers (Lidor et al., 2010, 2014). The first explanation was associated with the small size of the population in the investigated country, Israel, and, consequently, the relatively low number of children interested in participating in sports activities. In the last few years (2017–2019), the Central Bureau of Statistics in Israel has made an effort to present data on the number of children and youth (ages 7–18 years) who participate in different sports activities (Central Bureau of Statistics, 2019). However, despite this effort, no solid information has been made available on the number of children under the age of 14 who engage in competitive sports activities in the country.

Since only a relatively small number of children in Israel select sports as their preferred activity, the selection process of the coaches is probably more flexible compared with coaches in other countries. That is to say, not only the strongest children in the given year are selected to be on the teams but also those who may be less strong in their abilities but possess a potential for future success. It was suggested that, because of Israel's small population and limited opportunities for participation in sports, children are not selected or "de-selected" for participation in sports according to their physical maturity.

The second explanation is the "open door" policy adopted by most of the clubs in the country. Since relatively few children participate in competitive sports activities, ball clubs struggle to recruit children for their specific sport. In essence, each club is competing with the other clubs to recruit more children. In general, the policy of the clubs is to enable a child who shows an interest in a particular ball game to join the team. The assumption of the sport policymakers is that those who are talented and motivated to excel will remain in the program for a longer period of time, and thus their abilities and skills will improve. In contrast, those who have less talent and are not highly motivated to achieve will eventually drop out.

The data discussed in Lidor et al. (2010, 2014) were collected on adult ballplayers who had reached the highest level of competitive sport in one local sports system. In line with the recommendations of Baker et al. (2018), in order to enable the analysis of long-term developmental trends associated with a local sports system, data on various environmental variables associated with this system—such as the RAE—should be collected continuously and compared across different periods of time. In the current study, we analyzed the RAE of young athletes in sports programs similar to the programs from which the RAE data were collected in the elite ballplayers in the two studies of Lidor et al. (2010, 2014). It was our aim to perform a follow-up analysis on these programs and to determine the existence/nonexistence of the RAE in young athletes, a decade after the initial data on this environmental variable were collected.

In addition, up to now, RAE data were obtained from young and adult female and male athletes without "listening" to the athletes' perceptions of this effect as it relates to their own athletic development, if indeed the effect does exist. It would be beneficial for coaches and policymakers to gather RAE-related information from the athletes themselves. It has recently been argued by Baker et al. (2020) that "To date, there has been scant research that has employed qualitative methodologies, leaving a gap in our understanding of how athletes perceive RAEs..." (p. 158). It is assumed that qualitative information that is collected from athletes can also assist coaches, policymakers, and sports directors to better cope with the asymmetrical distribution of athletes who were born early in the year compared with those who were born late in the year.

In only one study (Sherman and Hancock, 2016) was qualitative information gathered from athletes (ten 14- to 15-year-old competitive youth hockey players) and their parents on their awareness and perceptions of the RAE. It was found that none of the athletes had prior knowledge of the RAE, while most of the parents were aware of this phenomenon. In addition, the athletes perceived that players were often selected to teams based on their physical characteristics rather than athletic ability. The parents believed that the RAE was a result of relatively older athletes being more physically mature than the relatively younger athletes on the team. In another qualitative study (Andronikos et al., 2015), seven experts in the field of talent identification and development were interviewed on the existence, mechanisms, and possible solutions to RAEs. Inductive analysis of the data showed that while there was mixed evidence for the RAEs across sports, the eradication of RAEs was attributed to controllable features of the developmental environment. The factors discussed included the structure of categories used to group athletes within the sport (e.g., age and weight), recognition, and prioritization of long-term development over "short-term win focus."

Therefore, the purpose of our study was threefold: (a) to calculate the RAE in young Israeli elite athletes in both individual and team sports; (b) to study the athletes' initial approach toward the contribution of their date of birth to early success in sport, in light of the three principal social agents model proposed by Hancock et al. (2013), and particularly of the Galatea effect; and (c) to compare the RAE findings of this study with those of two previous studies on elite male (Lidor et al., 2010) and female (Lidor et al., 2014) Israeli ballplayers. In the current study, we adopted a follow-up approach—examining the RAE in athletes who participated in sports programs similar to the ones studied 10 years ago, as well as adding one more dimension to the collection of the RAE data: how the athletes associated their date of birth with various aspects of their training program. While in previous studies on the RAE in Israeli elite athletes only team sports were examined, in the current study, we analyzed the existence of the effect also in individual sports.

We assumed that the findings of the RAE phenomena in young athletes might differ after a 1-decade period due to new initiations or modifications in sport policy made by the local sports authorities. In Israel, for example, a national sports program was established in 2013, Sport's Flowers (see https://www.gov.il/en/departments/ministry_of_culture_and_sport), aimed at increasing the number of young female and male athletes who participate in organized sports activities. Such national initiations have the potential to influence a number of factors associated with early talent development in sports, among them the RAE.

METHOD

Participants

The RAE was assessed in 1,397 athletes aged 14–18 years (mean age = 16.37 years, SD = 1.54); among them are 390 females (mean age = 16.28 years, SD = 1.57) and 1,007 males (mean age = 16.40 years, SD = 1.53). The athletes competed in 10 different sports: 5 individual (gymnastics, judo, swimming, tennis, and track and field) and 5 team (basketball, soccer, team handball, volleyball, and water polo) sports. The numbers of male and female athletes in each sport are presented in **Tables 1**, **2**, respectively.

We are aware of the fact that the number of female athletes who participated in the current study is low ($n = 390$) compared to the number of male athletes. In our previous study on adult female ball players, the number of the female participants was similar ($n = 389$); however, this represented individuals from only four sports activities. The low number of female participants in the current study reflects the limited number of young active female athletes in Israel. For example, only 19% of the active athletes 13–18 years of age are females (see Central Bureau of Statistics, 2019). This small sample creates a dilemma: on the one hand, due to this small sample size of female athletes, the probability of revealing a significant finding in the RAE data is low. On the other hand, in order to discuss theoretical and practical implications of the RAE from the local sport system's perspective, the existence (or nonexistence) of the RAE should be analyzed. It was our preference to analyze the existence of the RAE in female athletes, taking into account the restrictions of the small sample size.

We selected 14 (as the early age) to 18 (as the late age) year-old athletes because these age categories represent two critical transitional phases in the early career of a young competitive athlete. The age of 14 years is considered to be a turning point from the developmental years to the specialization years (Côté et al., 2006), and the age of 18 years is considered to be a transitional stage from being part of a youth sports program to

TABLE 1 | Distribution of the male athletes' birth month and the results of the statistical analyses.

Quartile distribution (CD)	Quartile and number and percentage of players								
	Q1: 24.5%	**Q2: 23.3%**	**Q3: 26.4%**	**Q4: 25.9%**	**Total**	χ^2 ($df = 3$)	***p***	**Cramer's *V***	**Q1 *vs.* Q4: OR (95% CI)**
Gymnastics (%)	8 (44.44)	4 (22.22)	3 (16.67)	3 (16.67)	18	4.17	0.24	0.34	2.82 (0.44–18.08)
Expected	4.41	4.19	4.75	4.65					
Judo (%)	53 (30.29)	44 (25.14)	46 (26.29)	32 (18.29)	175	6.57	0.09	0.14	2.82 (0.95–3.21)
Expected	42.86	40.70	46.09	45.285					
Swimming (%)	38 (36.54)	26 (25.00)	24 (23.08)	16 (15.38)	104	11.16	0.01*	0.23	2.51* (1.13–5.56)
Expected	25.47	24.19	27.45	26.89					
Residual	12.53	1.91	−3.45	−10.89					
Tennis (%)	41 (32.28)	26 (20.47)	30 (23.62)	30 (23.62)	127	4.2	0.24	0.13	1.44 (0.73–2.85)
Expected	31.10	29.54	33.52	32.84					
Track and field (%)	7 (12.07)	18 (31.03)	18 (31.03)	15 (25.86)	58	5.64	0.13	0.22	0.49 (0.16–1.56)
Expected	14.20	13.49	15.30	15.00					
Basketball (%)	54 (34.18)	40 (25.32)	35 (22.15)	29 (18.35)	158	10.86	0.01*	0.19	1.97* (1.05–3.69)
Expected	38.70	36.75	41.70	40.86					
Residual	15.30	3.25	−6.70	−11.86					
Soccer (%)	87 (40.47)	41 (19.07)	47 (21.86)	40 (18.60)	215	30.14	0.00*	0.26	2.30* (1.35–3.91)
Expected	52.66	50.00	56.75	55.60					
Residual	35.34	−9.00	−9.75	−15.60					
Team handball (%)	16 (31.37)	18 (35.29)	6 (11.76)	11 (21.57)	51	8.66	0.03*	0.29	1.54 (0.52–4.57)
Expected	12.49	11.86	13.46	13.19					
Residual	3.51	6.14	−7.46	−2.19					
Water polo (%)	5 (14.29)	12 (34.29)	10 (28.57)	8 (22.86)	35	3.50	0.32	0.22	0.66 (0.15–2.83)
Expected	8.57	8.14	9.24	9.05					
Volleyball (%)	18 (27.27)	16 (24.24)	15 (22.73)	17 (25.76)	66	0.57	0.90	0.07	1.12 (0.43–2.89)
Expected	16.16	15.35	17.42	17.07					
Total	327	245	234	201	1,007				

Q1: January–March; Q2: April–June; Q3: July–September; Q4: October–December.
CD, census data.
$^*p \le 0.05$.

becoming a member of a professional/semi-professional adult sports program (Lidor et al., 2010). The athletes in this study participated in between four and six sessions of practice on a weekly basis, depending upon the given sport. In addition, they regularly competed in organized leagues and tournaments.

Typically, sports programs in Israel allow registration at the age of 8 years. The participants in our study had at least 6 years' experience in training and competition. However, in a number of sports, such as gymnastics, swimming, and soccer, children can enter the sports program even earlier than the age of 8 years, and thus some of them had gone through at least 9 years of training and competition. Therefore, the participants in our study were aged 14–18 years and could have participated in 6–9 years of activity in their selected sports. The study was approved by the ethics committee of the Academic College at Wingate.

RAE Calculations and Perceptions Related to the RAE

Since the mean age of the participants (females and males) in our study was 16.37 years (SD = 1.54) and the majority of the data in our study were collected in 2016, census data from the year 2000 were used. In this year, the distribution of the birth dates per quartile was as follows: Q1 (January–March), 24.5%; Q2 (April–June), 23.3%; Q3 (July–September), 26.4%; and Q4 (October–December), 25.9%. This distribution of the birth dates

TABLE 2 | Distribution of the female athletes' birth month and the results of the statistical analyses.

	Quartile and number and % of players								
Quartile Distribution (CD)	**Q1 (24.5%)**	**Q2 (23.3%)**	**Q3 (26.4%)**	**Q4 (25.9%)**	**Total**	**$\chi^2(df = 3)$**	***P***	**Cramer's V**	**Q1 vs. Q4 OR (95% CI)**
Gymnastics	11 (23.91%) 11.27	11 (23.91%) 10.70	11 (23.91%) 12.14	13 (28.26%) 11.89	46	0.22	0.97	0.05	089 (0.29; 2.81)
Judo	11 (21.57%) 12.49	16 (31.37%) 11.86	11 (21.57%) 13.46	13 (25.49%) 13.19	51	2.07	0.56	0.14	0.89 (0.29; 2.71)
Swimming	16 (32.00%) 12.25	15 (30.00%) 11.63	11 (22.00%) 13.20	8 (16.00%) 12.93	50	4.37	0.22	0.21	2.11 (0.66; 6.69)
Tennis	14 (26.92%) 12.74	13 (25.00%) 12.09	13 (25.00%) 13.72	12 (23.08%) 13.45	52	0.39	0.94	0.60	1.23 (0.42; 3.65)
Track and Field	6 (22.22%) 6.61	9 (33.33%) 6.28	9 (33.33%) 7.13	3 (11.11%) 6.98	27	3.99	0.26	0.38	2.11 (0.37; 12.12)
Basketball	22 (28.95%) 18.61	18 (23.68%) 17.68	22 (28.95%) 20.06	14 (18.42%) 19.65	76	2.44	0.48	0.13	1.66 (0.66; 4.17)
Soccer	8 (38.10%) 5.14	4 (19.05%) 4.88	7 (33.33%) 5.54	2 (9.52%) 5.43	21	4.30	0.23	0.32	4.22 (0.59; 30.09)
Team Handball	13 (37.14%) 8.57	9 (25.71%) 8.14	7 (20.00%) 9.24	6 (17.14%) 9.05	35	3.95	27.0	24.0	2.29 (60; 8.79)
Water Polo	0 (0.00%) -	0 (0.00%) -	1 (33.33%) -	2 (66.67%) -	3	-	-	-	-
Volleyball	10 (34.48%) 7.10	6 (20.69%) 6.74	11 (37.93%) 7.65	2 (6.90%) 7.50	29	6.76	0.80	0.34	5.28 (0.85; 32.99)
Total	111	101	103	75	390				

Q1: January–March; Q2: April–June; Q3: July–September; Q4: October–December.
CD, census data.

per quartile in the year 2000 was used as the expected distribution for the chi-square tests. Based on these data, we can observe that a similar distribution of birth dates across quartiles existed in this year. The comparison of the RAE data collected in the current study was based on this observation.

The athletes who participated in the current study were asked to answer in writing two closed questions related to the RAE. In question 1, the athletes were asked whether they felt that their birth date (the month they were born in the year) had an influence (positive/negative) on the way they were able to develop their athletic abilities/skills. The athletes were given two options: "yes" or "no." They had to select one of the two options and to encircle the selected one. They were not asked to add any more written information.

In question 2, the athletes were asked whether they felt that they had any strengths/limitations in one or more of the following four pillars of the training program—physical, cognitive, emotional, and social—compared to their peers in the sports program. We selected these four pillars because they are considered the foundation for any sports program aimed at improving abilities/skills in a young athlete (see, e.g., Bompa and Buzzichelli, 2018; Bompa et al., 2019).

The athletes were provided with written information about the meaning of the four selected pillars and their association with sport-related abilities and skills. The athletes were informed that (a) the term *physical pillar* is associated with technique, as well as athletic abilities such as agility, coordination, flexibility, and speed; (b) the term *cognitive pillar* is associated with processes, such as decision making and game understanding (for the players who played team sports); (c) the term *emotional pillar* is related to internal and external motivation, self-confidence, and self-discipline; and (d) the term *social pillar* is related to leadership and team cohesion.

In question 2, the athletes were given four options: "physical pillar," "cognitive pillar," "emotional pillar," and "social pillar." They were asked two questions about these pillars: (a) Do you feel that you have any strengths in one or more of the following four pillars of the training program—physical, cognitive, emotional, and social—compared to your peers in the sports program?, and (b) Do you feel that you have any limitations in one or more of the following four pillars of the training program—physical, cognitive, emotional, and social—compared to your peers in the sports program? The athletes had to select one or more of the four options and to encircle the selected one/s for each question. They were not asked to add any more written information.

Procedure

Information about an athlete's birth date, gender, and his or her type of sport were collected *via* questionnaires, which also included the two RAE-related questions. The questionnaires were administered to the athletes by their coaches. Each director of the sports program where the athletes who participated in the study practiced received a letter providing the background and objectives of the study. All of the directors approved the study. In addition, informed consent was obtained from the parents of the participants. After approval was obtained, the second author approached the coaches of the athletes and sent them the questionnaires *via* electronic mail.

All of the coaches who were approached ($n = 68$; 14 females and 54 males, all certified by their sports federations) agreed to gather the required information from their athletes. The coaches administered the questionnaires, collected them, and sent them back to the researchers. The administration of the questionnaires to the athletes was performed manually, so that any questions relating to question 1 and question 2 that were raised by the athletes could be addressed directly by the coaches. Prior to the administration of the questionnaires, the coaches were provided with detailed information about the study. They were also prepared to answer other questions that could have been raised by the athletes, particularly those related to their birth date (early or late in their cohort year) and the four pillars (e.g., the meaning of the physical pillar, the cognitive pillar, etc.).

We collected the data on the RAE *via* such a process since information on the birth dates of the athletes could not be obtained from the official websites of the relevant sports federations or the specific sports programs. We had also faced this challenge in previous studies examining the RAE in elite male and female ballplayers in Israel (Lidor et al., 2010, 2014).

Data Analysis

A chi-square (χ^2) test was performed to determine the significance of deviations for the expected number of birth dates in each quartile of the selected year. The chi-square test does not reveal the magnitude of difference between the quartiles' distributions for the significant chi-square outputs. Therefore, in line with the RAE analyses of Kelly et al. (2020), Cramer's *V* was also performed. Odds ratios (ORs) and 95% confidence intervals (CIs) were also used to compare the quartiles for the observed and expected distributions.

The birth date of each athlete in each sport was recorded to represent his or her birth quartile (Q). Four quartiles were designated: Q1 = January–March; Q2 = April–June; Q3 = July–September; and Q4 = October–December. Athletes who were born in Q1 were considered to be relatively older than those who were born in Q4. Chi-square tests were also used to analyze the data collected from question 1 and question 2. The analysis was performed separately for the male and female athletes and for the individual and team sports.

RESULTS

Results are presented separately for the RAE, question 1, and question 2. As indicated previously, the sample size of the female athletes was relatively small. However, it was our aim to analyze their data separately in order to obtain information on each gender and on each sport. In this way, we are able to strengthen our understanding of the existence of the RAE in the various sports programs available to female and male children and youth in the country.

Relative Age Effect

Male Athletes

The frequency and percentage distribution of the male athletes' birth months and the results of the χ^2 test are presented in **Table 1**. The χ^2 test showed that the RAE was significant in male athletes in one individual sport, swimming ($p < 0.01$), and in three team sports, basketball ($p < 0.01$), soccer ($p < 0.001$), and team handball ($p < 0.03$). In swimming, basketball, and soccer, those who were born in Q1 had a higher representation in the elite youth programs compared to those who were born in Q2, Q3, and Q4. In team handball, those who were born in Q2 had a higher representation in the elite youth program compared to those who were born in Q1, Q3, and Q4. It can be observed in the abovementioned four sports that the number of athletes who were born in the early phases of the year was significantly higher than the number of those who were born in the late phases of the year.

Female Athletes

The frequency and percentage distribution of the female athletes' birth months and the results of the χ^2 test are presented in **Table 2**. The RAE was not found to be significant among the female athletes in any of the analyzed sports. That is to say, a similar number of individuals from each quartile were selected to participate in the designated sport programs.

Question 1

All the athletes (females and males) who participated in the study answered question 1. Among the male athletes, the majority (79.2%) reported that they did not feel that their date of birth influenced their athletic development, while only 20.8% perceived it as a contributing factor [χ^2 (1) = 343.18, $p <$ 0.001]. More specifically, 77.2% of the male athletes in the individual sports and 81% in the team sports reported that they did not perceive their birth date as an influential factor in their athletic development.

Similar findings were found for the female athletes. The majority of the female athletes (88.2%) did not perceive their birth date as an influential factor in their sports development, leaving only 11.8% who perceived their birth date as being influential [χ^2 (1) = 226.76, $p < 0.001$]. More specifically, 85.3% of the female athletes in the individual sports and 92.1% in the team sports reported that they did not perceive their birth date as a contributing factor to their athletic development.

A comparison between the male and female athletes revealed that a greater portion of the males (20.8%) perceived their date of birth as a contributing factor to their success than did the females (11.8%) [χ^2 (1) = 15.6, $p < 0.001$].

Question 2

Among the male athletes, 840 out of 1,097 (77%) answered question 2. Among the female athletes, 310 out of 390 (79.4%) who participated in the study answered this question. The data (number of athletes, percentage of athletes, χ^2 values, and level of significance) on how the male and female athletes who perceived themselves as having strengths in the four pillars of the training program are presented per quartile in **Tables 3**, **4**, respectively.

Five main findings emerged from the data analyses. Firstly, the athletes preferred sharing their perspectives about their strengths in the four pillars rather than about their limitations. More specifically, among the 840 male athletes who answered this question, 617 (73%) shared their feelings about their strengths and only 223 (27%) added information about their limitations. Similar findings were obtained for the female athletes: among the 310 athletes who answered this question, 207 (67%) reported about their strengths and 103 (33%) about their limitations.

Secondly, among the four pillars of the training program, more male and female athletes in both individual [181 (37.4%) and 66 (29.2%), respectively] and team [201 (38.1%) and 70 (42.7%), respectively] sports associated their strengths with the physical pillar rather than with any of the other pillars. Similar findings were obtained for those athletes who provided information about having limitations: 161 out of 223 (72%) male athletes and 77 out of 103 (74%) female athletes related their limitations to the physical pillar.

Thirdly, for the male athletes in individual sports, it was found that those who were born in Q1 ($n = 64$; 35.4%) and Q2 ($n = 46$; 25.4%) believed that they were superior to their peers who were born in Q3 ($n = 37$; 20.4%) and Q4 ($n = 34$; 18.8%). More specifically, those who were born early in the year felt that they were superior in their techniques in comparison to their counterparts who were born late in the year. In addition, those who were born in Q1 and Q2 perceived themselves as better athletes with regard to their agility, coordination, flexibility, and speed than their peers who were born in Q3 and Q4.

Fourthly, a similar observation as the one made for the male athletes in individual sports can be made for the male athletes in team sports. More athletes who were born in Q1 ($n = 73$; 36.3%) and Q2 ($n = 53$; 26.4%) believed that they had greater physical strengths compared with those who were born in Q3 ($n = 42$; 20.9%) and Q4 ($n = 33$; 16.4%). In addition, it was found for the male athletes in team sports that more athletes who were born in Q1 ($n = 28$; 35.9%) and Q4 ($n = 25$; 32.1%) believed that they had greater cognitive strengths compared to those who were born in Q2 ($n = 9$; 11.5%) and Q3 ($n = 16$; 20.54%). In other words, those who were born early in the year (Q1), as well as those who were born in the last phase of the year (Q4), felt that they were better in their decision-making and game-understanding processes than those who were born in Q2 and Q3.

Lastly, no significant differences were found in how the female athletes who were born in any of the four quartiles perceived their strengths/limitations in the four pillars of the training program.

DISCUSSION

Three main findings emerged from the current study. Firstly, the RAE was found to be significant only in the male athletes and in only four out of the 10 investigated sports. More specifically, the effect was found in swimming (an individual sport) and in basketball, soccer, and team handball (team sports). In the female athletes, the RAE did not exist. Secondly, both female and male athletes did not feel that their birth date had any relation to their athletic achievement. Thirdly, when asked whether they felt that they had any strengths/limitations in the four basic pillars of the training program—physical, cognitive, emotional, and social—compared to their peers in the program, most of the athletes (both females and males) related to their strengths rather than to their limitations. Specifically, male athletes who were born in Q1 and Q2 felt that they had more physical strengths compared to those who were born in Q3 and Q4. Those who were born in Q1 among the male athletes believed that they also had more cognitive strengths compared to their peers who were born in Q2 and Q3. However, those who were born in Q4 felt the same, namely that they had more cognitive strengths compared to those who were born in Q2 and Q3.

Relative Age Effect

The RAE data obtained in the current study are partially in line with those reported in previous studies. On the one hand, the finding that RAE was present in males in four sports is in line with previous findings (e.g., Côté et al., 2006; Baker and Logan, 2007; Schorer et al., 2009). On the other hand, the finding that the RAE did not exist in the male athletes in six out of the 10 analyzed sports and the finding that the RAE was not found in the female athletes altogether are not in line with the majority of the previous findings on the RAE (see reviews by Cobley et al., 2009; MacDonald and Baker, 2013; Sierra-Díaz et al., 2017; Smith et al., 2018). However, the nonexistence of the RAE in most of the sports examined in the current study (a combined 16 out of 20 activities for both female and male athletes) is in line with the findings of RAEs reported in earlier studies on Israeli elite sport performers (Lidor et al., 2010, 2014).

We offer two explanations for the RAE data obtained in our study. Firstly, in most of the analyzed sports where the RAE did not exist, the coaches who recruited children to the sports programs continued to implement the "open door" policy, as described by Lidor et al. (2010, 2014). According to this policy, children who are selected to join a sports program in Israel are encouraged to continue their sports experience, even though some of them do not demonstrate the physical attributes required to achieve a high level of proficiency in sports. It is assumed that this policy enables those who are considered to be late bloomers to continue their sports participation and

TABLE 3 | Distribution across quartiles of the male athletes who felt they had strengths in the four pillars.

Sport	Pillar	Q1		Q2		Q3		Q4		Total		χ^2	*p*
		N	%	*N*	%	*N*	%	*N*	%	*N*	%		
Individual	Physical	64	35.4	46	25.4	37	20.4	34	18.8	181	37.4	12.08	0.01*
	Cognitive	15	38.5	8	20.5	10	25.6	6	15.4	39	8.1	4.59	0.20
	Emotional	16	33.3	10	20.8	13	27.1	9	18.8	48	9.9	2.50	0.48
	Social	0	0.0	1	25.0	2	50.0	1	25.0	4	0.8	2.00	0.57
Team	Physical	73	36.3	53	26.4	42	20.9	33	16.4	201	38.1	17.73	0.00*
	Cognitive	28	35.9	9	11.5	16	20.5	25	32.1	78	14.8	11.54	0.01*
	Emotional	14	31.8	8	18.2	12	27.3	10	22.7	44	8.3	1.82	0.61
	Social	10	45.5	4	18.2	4	18.2	4	18.2	22	4.2	4.91	0.18

*$p < 0.05$.

TABLE 4 | Distribution across quartiles of the female athletes who felt they had strengths in the four pillars.

Sport	Pillar	Q1		Q2		Q3		Q4		Total		χ^2	*p*
		N	%	*N*	%	*N*	%	*N*	%	*N*	%		
Individual	Physical	21	31.8	19	28.8	15	22.7	11	16.7	66	29.2	3.58	0.31
	Cognitive	2	11.8	7	41.2	6	35.3	2	11.8	17	7.5	4.88	0.18
	Emotional	6	31.6	7	36.8	5	26.3	1	5.3	19	8.4	4.37	0.22
	Social	1	20.0	3	60.0	1	20.0	0	0.0	5	2.2	3.80	0.28
Team	Physical	23	32.9	15	21.4	21	30.0	11	15.7	70	42.7	5.20	0.16
	Cognitive	3	27.3	3	27.3	3	27.3	2	18.2	11	6.7	0.27	0.97
	Emotional	6	40.0	2	13.3	4	26.7	3	20.0	15	9.1	2.33	0.51
	Social	2	50.0	1	25.0	0	0.0	1	25.0	4	2.4	2.00	0.57

become part of an effective training environment with highly qualified coaches.

The second explanation is associated with the popularity of ballgame activities in Israel. More specifically, soccer and basketball—followed by volleyball and team handball—are considered to be the most popular sports in Israel (see Lidor and Blumenstein, 2012). For example, the Central Bureau of Statistics (2019) reported that, in 2017–2018, 48,799 children and youth (ages = 12–17 years) were active in ballgame activities in Israel, about 4% of the total population at this age. Among them, 40.9% (n = 29,808) were soccer players and 26,697 (36.8%) were basketball players. The rest of the children and youth (22%) were active in 16 different ballgame activities (including team handball and volleyball). Therefore, due to the fact that there are far more children in basketball and soccer who want to be part of a talent development program than in other sports, basketball and soccer coaches do not adopt the "open door" policy as is done in the other sports, but instead implement a more cautious approach in their early selection processes. That is to say, coaches select those who are more fit physically for contact sports such as soccer and basketball. This is also true for the game of team handball, where the RAE was found to be significant in the male athletes, although the number of children who are interested in playing team handball is much smaller than those who have an interest in soccer and basketball.

In the less popular sports, coaches are somewhat obliged to select children who are not necessarily advanced in their physical development since there are only a small number of children who show interest in these sports contexts. It has already been suggested that the lack of competition can serve as a moderator for the RAE (Musch and Grondin, 2001; Schorer et al., 2009).

The sport of swimming seems to be an interesting RAE case in our study. Swimming is considered a minor individual sport in Israel, but the RAE did exist in the male swimmers who participated in our study. In the years 2017–2018, there were only 321 active competitive swimmers in Israel between the ages of 7 and 24 years. About 55% of them were active between the ages of 7 and 11 years and about 43% between the ages of 12 and 17 years. Although not many children selected swimming as their preferred sport, we assume that the RAE did exist in the young male swimmers due to the fact that the time allocated to practice sessions in the community swimming pools is limited for competitive swimmers, and therefore the coaches are obliged to select only the best in their age group to be included in the team.

Perceptions About Issues Related to the RAE

Up to now, only one study has examined the perceptions of athletes concerning various aspects associated with the RAE (Sherman and Hancock, 2016). Since only limited information was collected in questions 1 and 2, we adopted a cautious approach in our attempts to interpret the athletes' responses. Two observations can be made based on the analysis of the athletes' responses. Firstly, most of the athletes did not think that their birth date is associated with athletic development; those who were born early in the year did not refer to it as a contributing factor to their success, while those who were born late in the year did not relate to it as an obstacle to achieving success. In question 1, the athletes were not asked about their prior knowledge of the RAE. It is possible that they were familiar with the term, or perhaps they were not. We assumed that they were not familiar with the specific term RAE; however, after 6–9 years of experience in their selected sports, the athletes probably could relate to their date of birth (early or late in the year) as a potential variable associated with their athletic achievements. It is suggested that, in future studies on the RAE, the effect should be related to the athletes' early sport development.

This finding is somewhat in line with the finding that emerged from Sherman and Hancock's (2016) study, namely that the young competitive hockey players had no prior knowledge of the RAE. In both studies, the young athletes (14–18 years old in our study and 14–15 years old in Sherman and Hancock's study) did not consider the RAE as a contributing/interfering variable to their athletic performance. Taking into account (a) the finding that the RAE was found to be significant in only four sports in the male athletes and (b) the finding that the athletes themselves did not value this effect as a contributing factor to their success, we can speculate that the coaches did implement an "open door" approach in the early phases of talent selection. It appears that the coaches provided children with a real opportunity to be part of the sports programs, regardless of whether they were born early or late in the given year.

Secondly, when asked about their strengths/limitations compared to their peers in the sports program, the male athletes who were born early in the year (Q1 and Q2) felt that they had more strengths in the physical pillar of the program compared to their counterparts who were born late in the year (Q3 and Q4). This observation is somewhat contradictory to the feelings the athletes reported in question 1. However, we assume that by introducing the four pillars to the athletes, and not merely providing a general concept of the RAE as we did in question 1, those who were born in Q1 and Q2 could refer more specifically to their strengths/limitations compared to their peers who were born late in the sports program. In addition, we assume that most of the athletes referred mainly to their physical strengths since the physical pillar is the one among the four pillars that is most associated with the athletic/sports domain (Bompa and Buzzichelli, 2018). Support for this finding was found in Sherman and Hancock's (2016) study, where the young players believed that players were often selected to teams based on their physical characteristics rather than on their athletic ability.

We assume that the finding that male athletes who were born early in the year (Q1 and Q2) felt that they exhibited more strengths in the physical pillar of the program compared to their counterparts who were born late in the year (Q3 and Q4) can also explain why a small portion of the male athletes (20.8%) perceived their date of birth as a contributing factor to their success. These athletes, as well as the 12% of the female athletes who also believed that their date of birth was a contributing factor to their success, apparently attributed achieving early success in sports to their more mature physical characteristics (see Sherman and Hancock, 2016). They viewed the physical pillar as the one which contributed the most to early achievements in sports rather than the cognitive, emotional, or the social pillar. This assumption should be further examined in additional qualitative studies.

The male athletes who were born in the different quartiles of a given year also differed in how they perceived their strengths/limitations in the cognitive pillar. However, in this case, not only those who were born early in the year (Q1) but also those who were born late in the year (Q4) felt that they had strengths in the cognitive pillar compared to those who were born in Q2 and Q3. For those who were born in Q1, it can be suggested that they were probably more experienced and therefore also felt superior in the cognitive pillar compared to their peers who were born late in the year. For those who were born in Q4, it can be speculated that they felt superior in the cognitive pillar, perhaps in order to convince themselves that, although they were not as physically strong as the ones who were born early in the year, they still could have positive achievements because they were stronger cognitively than their older peers in the program. Presumably, the latter explanation should be further examined in additional RAE studies.

The finding that male athletes who were born early in the year (Q1 and Q2) felt that they had (a) more strengths in the physical pillar of the program compared to their counterparts who were born late in the year (Q3 and Q4) and (b) more strengths in the cognitive pillar compared to those who were born in Q3 can be explained by the RAE theoretical framework proposed by Hancock et al. (2013). According to this model, the influence athletes have on the RAE is due to the Galatea effect (see Merton, 1957) or to the self-expectations that athletes possess: once expectations are placed upon an individual, that individual typically acts congruently with those expectations. Since social agents, such as coaches and parents, may expect the older athletes to achieve better than those who were born late in the program, the older athletes match themselves up with those expectations. They actually not only believe that they have better abilities than their younger counterparts but also act according to these expectations, thereby achieving a higher level of proficiency in their sport. As argued by Hancock and colleagues "… as athletes buy into those expectations, they raise their self-expectations, affording continued success" (p. 634).

We can use the RAE theoretical model of Hancock et al. (2013) to also explain the finding that those who were born late in the year (Q4) felt, as did those who were born in Q1, that they had strengths in the cognitive pillar compared to those who were born in Q2 and Q3. We assumed that the relatively younger athletes who had succeeded to be part of the competitive sports program also possess high self-expectations since they were already part of the program. Probably, the relevant social agents (e.g., coaches and parents) also expect them to attain success, at least in the cognitive pillar of the program (e.g., making an accurate decision in a ballgame activity).

Since one of our purposes in the current study was to explore how 14- to 18-year-old athletes perceived a number of aspects associated with the RAE, we provided them with a limited number (two) of closed questions. In order to strengthen our understanding of what athletes think about relevant environmental variables associated with their early athletic development, as well as of what other social agents involved in the long-term process of athletic development—such as coaches and parents—think about these variables, additional qualitative information should be collected. For example, performing follow-up interviews with selected athletes from each gender and from each sport has the potential to add value to the findings that emerged from our study. The qualitative approach used by Sherman and Hancock (2016) is promising, and the responses from in-depth interviews with the relevant stakeholders should be gathered and assessed.

Organizational and Structural Considerations—Looking Back and Forward

The combined RAE findings of the current study (excluding those on four sports in the male athletes), as well as of previous studies on male and female elite ballplayers in Israel (Lidor et al., 2010, 2014), provide support for the nonexistence of the RAE in young and adult Israeli athletes. Due to the unique characteristics of the local sports system, among them that not many children are involved in sports and those who are involved in sports prefer to be part of "big sports" programs such as soccer and basketball, coaches and policymakers cannot be meticulous in their early selection of children to the designated sport programs. In essence, they enable all interested children to join sports programs and therefore provide them with various educational–instructional learning opportunities to acquire sports skills. It can be concluded that the local sports system in Israel has been able to maintain the use of the "open door" approach over the past 10 years.

However, the existence of the RAE in a number of sports in the current study may demonstrate a change in the selection policy in the "big sports" (i.e., basketball, soccer, and team handball) compared to the policy used a decade ago. If the "open door" policy does not currently exist in the "big sports" programs in Israel, at least in the male athletes, policymakers are advised to be aware of this trend and to make efforts to encourage children who are deselected from the "big sports" programs to transfer to other programs where they can develop their abilities/skills as well. If those children who are not initially selected to the "big sports" programs withdraw from all sport participation, then the total number of children who are involved in sports in Israel may become even smaller.

Based on the written responses of the athletes to questions 1 and 2, it might be proposed—although cautiously—that prior to the implementation of imposed actions aimed at preventing/eliminating the RAE, information from the athletes themselves should be gathered in order to study how they perceive this effect. As was found in our study, athletes may not consider their birth date in a given year (early or late) as a contributing/interfering factor to their athletic performance. Indeed, male athletes who were born early in the year felt that they had a larger number of physical and cognitive strengths compared to those who were born early in the year. However, those who were born late in the year did not feel that they had any physical or cognitive limitations compared to those who were born early in the year. In fact, the opposite is true—those who were born in Q4 felt that had more cognitive strengths compared to those who were born in Q2 and Q3 in the same year. We argue that listening to the athletes themselves may aid in searching for effective organizational strategies on how to deal with the RAE, if indeed the effect exists in young athletes.

The main difference between the data that emerged from the previous studies on the RAE in elite athletes in Israel (Lidor et al., 2010, 2014) and the data of the current study is that while in the previous studies the effect was not found, in the current study, the RAE was found to be significant in three team sports and one individual sport in the male athletes. Indeed, this difference may be considered small. However, the existence of the effect in the three most popular sports in the country can provide policymakers with evidence-based data on how to develop current and future sport programs for children and youth. For example, a national sports program was established in 2013 in Israel (see https://www.gov.il/en/departments/ministry_of_culture_and_sport) in order to increase the number of children in sports activities. This national program was composed of various sports, including the most popular ballgame activities in the country: soccer and basketball. It might be more beneficial for policymakers to promote sports programs where the RAE does not exist, thereby enabling more children to join the programs and enjoy early positive sports experiences. It has already been argued that a number of factors, among them the popularity of a given sport, the number of active participants, the importance of physical development, and the competitive level, may influence the magnitude of the RAE (Musch and Grondin, 2001; Romann et al., 2020). Apparently, the RAE that was found in basketball, soccer, and team handball in the current study is associated with the high rates of participation and high selection pressure in these sports.

CONCLUSION

In order to validate the existence/nonexistence of the RAE as an environmental factor associated with achieving superiority in sports in a local sports system, data related to this effect should be collected continuously over a long-term period. These data can assist professionals who are involved in processes of early talent selection/development, among them coaches and policymakers, to reflect upon the decisions they are required to make throughout these processes. In addition, the voice of the athletes should also be heard in order to strengthen the interpretation of the numerical RAE data collected from them.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The ethics committee of the Academic College at Wingate. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

RL and ZM: conceptualization and methodology. ZM: data collection. RL: writing original draft. MA: data analysis. All authors contributed to the article and approved the submitted version.

REFERENCES

Andronikos, G., Elumaro, A. I., Westbury, T., and Martindale, J. J. (2015). Relative age effect: implications for effective practice. *J. Sports Sci.* 34, 1124–1131. doi: 10.1080/02640414.2015.1093647

Baker, J., Chittle, L., Horton, S., and Dixon, J. C. (2020). "Concluding thoughts and future research on relative age effects in sport," in *Relative Age Effects in Sport—International Perspectives,* eds J. C. Dixon, S. Horton, L. Chittle, and J. Baker (New York, NY: Routledge), 154–161. doi: 10.4324/97810030 30737-12

Baker, J., and Logan, A. J. (2007). Developmental contexts and sporting success: birth date and birthplace effects in national hockey league draftees 2000-2005. *Br. J. Sports Med.* 41, 515–517. doi: 10.1136/bjsm.2006. 033977

Baker, J., Schorer, J., Cobley, S., Schimmer, G., and Wattie, N. (2009). Circumstantial development and athletic excellence: the role of birth date and birth place. *Eur. J. Sport Sci.* 9, 329–339. doi: 10.1080/174613909029 33812

Baker, J., Schorer, J., and Wattie, N. (2018). Compromising talent: issues identifying and selecting talent in sport. *Quest* 70, 48–63. doi: 10.1080/00336297.2017.1333438

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *Can. Assoc. Health Phys. Ed. Recreat.* 51, 23–28.

Barrenetxea-Garcia, J., Torres-Unda, J., Esain, I., and Gill, S. M. (2018). Relative age effect and left-handedness in world class water polo male and female players. *Laterality.* 24, 259–273. doi: 10.1080/1357650X.2018. 1482906

Bompa, T., Blumenstein, B., Hoffmann, J., Howell, S., and Orbach, I. (2019). *Integrated Periodization in Sports Training and Athletic Development.* London: Meyer and Meyer Sport.

Bompa, T., and Buzzichelli, C. A. (2018). *Periodization—Theory and Methodology of Training, 6th Edn.*. Champaign, IL: Human Kinetics.

Côté, J., MacDonald, D. J., Baker, J., and Abernethy, B. (2006). When "where" is more important than "when": birthplace and birthdate effects on the achievement of sporting expertise. *J. Sports Sci.* 24, 1065–1073. doi: 10.1080/02640410500432490

Central Bureau of Statistics (2019). Athletes actively engaging in individual and team sports, financed by the sports authority, by sport and age. Available online at: https://www.cbs.gov.il (accessed October 9, 2020).

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development—a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Dixon, J. C., Horton, S., Chittle, L., and BakerBaker, J. (eds.). (2020). *Relative Age Effects in Sport—International Perspectives.* New York, NY: Routledge. doi: 10.4324/9781003030737

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Hill, B., and Sotiriadou, P. (2016). Coach decision-making and the relative age effect on talent selection in football. *Eur. Sport Manag. Q.* 16, 292–315. doi: 10.1080/16184742.2015.1131730

Jones, B. D., Lawrence, G. P., and Hardy, L. (2018). New evidence of relative age effects in "super-elite" sportsmen: a case for the survival and evolution of the fittest. *J. Sports Sci.* 36, 697–703. doi: 10.1080/02640414.2017. 1332420

Kelly, A. L., Jackson, D. T., Taylor, J. J., Jeffreys, M. A., and Turnnidge, J. (2020). "Birthday-banding" as a strategy to moderate the relative age effect: a case study into the England squash talent pathway. *Front. Sport Act. Liv.* 2:145. doi: 10.3389/fspor.2020.573890

Lidor, R., Arnon, M., Maayan, Z., Gershon, T., and Côté, J. (2014). Relative age and birthplace effects in Division 1 female players—the relevance of sport-specific factors. *Int. J. Sport Exerc. Psychol.* 12, 19–33. doi: 10.1080/1612197X.2012.756232

Lidor, R., and Blumenstein, B. (2012). "Soccer as a mediator for fostering relationships and building peace among Jewish and Arab players," in *Sport for Development, Peace, and Social Justice,* eds R. J. Schinke and S. J. Hanrahan (Morgantown, WV: Fitness Information Technology), 39–55.

Lidor, R., Côté, J., Arnon, M., Zeev, A., and Cohen-Maoz, S. (2010). Relative age and birthplace effects in Division 1 players—do they exist in a small country? *Talent Dev. Excell.* 2, 181–192. doi: 10.1080/1612197x.2012. 756232

MacDonald, D. J., and Baker, J. (2013). "Circumstantial development: Birthdate and birthplace effects on athlete development," in *Conditions of Children's Talent Development in Sport,* eds J. Côté and R. Lidor (Morgantown, WV: Fitness Information Technology), 197–208.

MacDonald, D. J., Cheung, M., Côté, J., and Abernethy, B. (2009). Place but not date of birth influences the development and emergence of athletic talent in American football. *J. Appl. Sport Psychol.* 21, 80–90. doi: 10.1080/10413200802541868

Merton, R. K. (1957). *Social Theory and Social Structure.* Glencoe, IL: The Free Press.

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Newell, K. M. (1986). "Constraints on the development of coordination," in *Motor Development in Children: Aspects of Coordination and Control*, eds M. G. Wade and H. T. A. Whiting (Amsterdam: Martin Nijhoff), 341–361. doi: 10.1007/978-94-009-4460-2_19

Romann, M., Rüeger, E., Hintermann, M., Kern, R., and Faude, O. (2020). Origins of relative age effects in youth football—A nationwide analysis. *Front. Sport Act. Liv.* 2. doi: 10.3389/fspor.2020.591072

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., and Baker, J. (2009). Influence of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scand. J. Med. Sci. Sports* 19, 720–730. doi: 10.1111/j.1600-0838.2008.00838.x

Sherman, A., and Hancock, D. J. (2016). Awareness and perceptions of relative age effects: a case study analysis. *J. Sport Exerc. Psychol.* 38 :S255.

Sierra-Díaz, M. J., González-Víllora, S., Pastor-Vicedo, J. C., and Serra-Olivares, J. (2017). Soccer and relative age effect: a walk among elite players and young players. *Sports* 5. doi: 10.3390/sports50 10005

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Thompson, A. H., Barnsley, R. H., and Steblelsky, G. (1991). "Born to play ball": The relative age effect and major league baseball. *Sociol. Sport J.* 8, 146–151. doi: 10.1123/ssj.8.2.146

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: A developmental system model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

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Confusion Reigns: An Analysis of Responses to U.S. Soccer Age Cut-Off Date Policy Change

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Relative age effects (RAEs) have been associated with the common practice of grouping athletes by chronological age. Development and selection advantages are often awarded to those who are born closer to, but following, the cut-off date employed by sport systems. In 2015, the U.S. Soccer Federation announced that it would be changing its birth-year registration cut-off date from August 1st to January 1st. This change was introduced to align the U.S. youth soccer calendar with international standards, and simultaneously provide clearer information on player birthdates to "lessen" RAEs. The magnitude of this policy change has led to considerable controversy, with members of the soccer community taking to social media and website blogs, as well as the U.S. Youth Soccer's website, to voice their opinions and general unhappiness with this decision. Thus, the purpose of this study was to provide a summary of online reactions to the policy change, with attention to the manner in which the U.S. Soccer Federation framed (i.e., the underlying rationale for the decision) and publicly communicated its decision to change the annual cut-off date. Qualitative content analysis was used to analyze data collected from 63 social media sites (websites, $n = 43$; forums, $n = 16$; blogs, $n = 4$). From the 3,851 pages of text derived from these sources, a total of 404 unique passages of text were identified within 262 stakeholder posts. Four categories emerged from the data: stakeholder discussion, outcomes identified by stakeholders, recommended courses of action, and communication regarding the policy change. In general, the actions of the U.S. Soccer Federation and related outcomes were negatively perceived by stakeholders at various levels of the sport. Resistance to the change may have been reduced through enhanced communication from the national level and opportunities for stakeholder input. While one objective of this policy change was to combat RAEs, previous research suggests this organizational change will only shift which group of athletes experience relative age (dis)advantages. There appears to be a disconnect between the academic literature and sport policy with respect to solutions for RAEs, which can lead to unintended consequences for various sport stakeholders.

Keywords: U.S. soccer, age cut-off, date change, policy change, organizational change, relative age, youth sport, stakeholder response

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INTRODUCTION

Relative age effects (RAEs) describe disparities in developmental outcomes that have been associated with the common practice of grouping children and youth by chronological age (Barnsley et al., 1985; Wattie et al., 2008). The use of these age groupings is well-intended, with the aim to provide developmentally appropriate instruction and competition. Yet, evidence to the contrary has been compiled in various domains such as organized sport participation (e.g., Cobley et al., 2009; Smith et al., 2018), academic performance (e.g., Bedard and Dhuey, 2006), high school leadership activities (e.g., Dhuey and Lipscomb, 2008), and even chess (e.g., Helsen et al., 2016). Generally, advantages are associated with being born closer to, but following, the organizational cut-off date utilized by each respective system. While the underlying mechanism(s) is/are undetermined, it is generally accepted that it is multifactorial in nature with subtle differences in physical, psychological, and emotional maturity leading to inequities in selection and development opportunities (Musch and Grondin, 2001; Cobley et al., 2009). A variety of individual, task, and environmental constraints can also influence the magnitude of RAEs and the degree to which they promote or hinder development on an individual level (see Wattie et al., 2015 for further discussion).

In the realm of sport, athletes often compete for membership on elite or representative teams. In a system that uses December 31st as a cut-off to group athletes, an athlete born in January is approximately 10% older than an athlete born at the end of the selection year (e.g., December) during their 10th year of life, leading to potential differences in lived experience, which can be compounded by considerable variability in biological maturity from childhood through to adolescence (Musch and Grondin, 2001; Malina et al., 2004). This may result in coaches and talent development scouts confusing increased size and experience for talent, leading to a higher likelihood of selection and all of the related opportunities that follow for relatively older athletes (e.g., enhanced coaching, training, and competition; Helsen et al., 1998). In contrast, athletes born later in the selection year may experience deselection and ultimately disengage from sport if unable to overcome the disadvantages associated with being relatively younger (MacDonald and Baker, 2013).

Sport researchers have given considerable attention to RAEs and the literature is saturated with documented birthdate trends that suggest these phenomena are present in a variety of sport contexts and age groups, among both male and female athletes around the world (see Cobley et al., 2009 and Smith et al., 2018 for reviews of male and female samples, respectively). Reports of increased awareness among sport administrators and the general public have also surfaced, including discussion of RAEs in popular media. For instance, Gladwell (2008) highlighted an over-representation of Canadian junior ice hockey players born early in the selection year in the opening chapter of his book entitled *Outliers: The Story of Success*. However, this increased attention has not produced equivalent action in mitigating their effects (Wattie et al., 2015). A variety of interventions have been put forth including the use of smaller (Boucher and Halliwell, 1991) or rotating age bands (Barnsley et al., 1985), corrective adjustments to objective measures of performance (e.g., sprint time; Romann and Cobley, 2015), and age-ordered shirt numbering to provide real time information for talent scouts (Mann and van Ginneken, 2017). Yet, few have been implemented and evaluated on a large enough scale to have a meaningful impact. For example, Helsen et al. (2012) reported no change over a 10-year period (2000–2001 to 2010–2011) in professional soccer despite increased awareness and knowledge of RAEs in sport, highlighting the pervasiveness of the effect. The persistence of RAEs and associated lack of action could theoretically contribute to a reduction in the talent pool for future advancement in sport, if relatively younger athletes do not have the opportunity to develop their skills and advance to higher levels. These athletes may also be subject to negative sport experiences with the end result being withdrawal from participation (e.g., Lemez et al., 2014).

Given the widespread popularity of the sport of soccer around the world and the associated pressure to achieve success in international competition, it is not surprising that RAEs have been recognized as an obstacle to optimal athlete development in this sport context. In fact, soccer has been one of the most common contexts for documentation of inequitable birth trends (Cobley et al., 2009). The subjective nature of athlete selections (i.e., player-to-player comparisons carried out on the field of play by scouts and coaching staff; Baker et al., 2014) create opportunities for relative age bias to surface from the developmental level to elite teams competing on the international stage. In an attempt to address relative age-related concerns inherent in talent development and selection activities, the U.S. Soccer Federation announced in 2015 that it would be changing its birth-year registration cut-off date from August 1st to January 1st. This change was introduced to align the U.S. youth soccer calendar with international standards, and simultaneously provide clearer information on player birthdates to "lessen" RAEs (U.S. Soccer, 2017), suggesting an intended benefit to participants at all levels. However, the magnitude of this policy change led to considerable controversy, with members of the soccer community taking to social media and website blogs (e.g., Woitalla, 2015), as well as the U.S. Youth Soccer (2016) website to voice their opinions and general unhappiness with this decision. Thus, the purpose of this study was to provide a summary of the online response from stakeholders[1] (i.e., initial reactions and discussion) and the reported preliminary outcomes of this policy change at various levels of the sport, with attention to the manner in which the U.S. Soccer Federation framed (i.e., the underlying rationale for the decision) and publicly communicated (i.e., choice of mediums and language) its decision to change the annual cut-off date. Given the rarity of this type of change within a national sport organization and the extent of the impact at all levels of the sport (i.e., developmental to elite), the information

[1]In this study, the term *stakeholder* refers to any individual who expressed an opinion in an online forum regarding the U.S. Soccer Federation's policy change and may include (but is not limited to), athletes/soccer participants, parents, grandparents, coaches, board members in local/community soccer clubs, and representatives from sport governing agencies at various levels (e.g., state, regional, national). All stakeholders identified during data collection were given equal weight in this study.

gained from this analysis can inform future decisions of this nature at local, regional, and national governing levels across a variety of sport contexts.

MATERIALS AND METHODS

Data Sampling and Collection

Data collection occurred from April to August 2017 (i.e., approximately 2 years after the announcement was made in 2015 and immediately prior to the deadline for implementation). Qualitative data (i.e., stakeholder posts in online forums) were collected manually from various social media platforms and website blogs[2] (e.g., *Soccer America, World Class Coaching*). These sites were identified by searching "U.S. Youth Soccer" or "U.S. Soccer" in combination with specific key terms and phrases, including "cut-off date change," "age group change," "relative age effect," "RAE," "birthday cut-off," and/or "rule change birth year." When a potentially relevant online platform was identified (websites, $n = 43$; forums, $n = 16$; blogs, $n = 4$), the content was copied and pasted in its entirety into a master file. The compiled text (3,851 pages) was then reviewed in full to manually identify specific quotes related to any one of four criteria: (1) RAEs; (2) the associated policy change/announcement; (3) age group changes/issues, or; (4) organizational change. For example, if an online post stated that a player would gain/lose a developmental advantage as a result of the cut-off date change, the quote was retained for further analysis. Care was taken during this process to remove stakeholders' personal information from the compiled data (e.g., screen name, club name).

Data Analysis and Re-presentation

The procedural steps of *hierarchical content analysis,* as outlined by Sparkes and Smith (2014) were followed to analyze the data collected from 63 social media sites. Content analysis is useful for investigations of relevance to practitioners and policy makers when the goal is to provide a comprehensive summary of phenomena, while staying close to the "surface" of the data (Sandelowski, 2000). From the 3,851 pages of text that were derived from online mediums, 262 stakeholder posts were manually identified based on their relevance to the aforementioned topic. A preliminary review was conducted to achieve familiarity with the compiled data (i.e., *immersion*); this included reading through each stakeholder post. *Raw data themes* were identified and labeled with *tags*. These tags were *clustered* to generate a list of higher order *sub-themes* and *categories*; this list was then applied to the data, *cross-checked*[3] and reflexively modified to accommodate new insights when required to ensure the best fit for the data (Sparkes and Smith, 2014). Each respective tag (i.e., raw data theme) was assigned a maximum of one time per stakeholder post, but each post could contain one or more themes. A total of 404 unique passages of text were identified within the 262 stakeholder posts and categorized accordingly. Themes, sub-themes, and categories were organized in a table based on their hierarchical nature (as recommended by Sparkes and Smith, 2014), while being mindful of heterogeneity between each category. The themes, sub-themes, and categories were then summarized using descriptive statistics.

Trustworthiness and Quality

The online posts were collected from a variety of social media platforms and website blogs to ensure representation from a variety of stakeholders. Four of the five authors were familiar with relative age research in the context of sport and were therefore able to identify valid themes and sub-themes in the raw data for subsequent analysis. However, the caveat of this familiarity was also recognized, that being the potential for personal bias in the construction of themes and the subsequent hierarchical organization of those themes. To address this limitation, a random selection of the compiled quotes (approximately one third of the total number of quotes) were independently evaluated by two authors[4] and compared to assess the objectivity of the coding process. Disagreements were resolved through discussion and a revision of the coding structure ensued. A second round of comparison and *confirmation* (Sparkes and Smith, 2014) followed with another co-author[5]; this included critical dialogue and feedback on the compiled themes, sub-themes, and categories. A final review of the data followed to ensure consistent assignment of categories within the dataset.

RESULTS

Our qualitative content analysis revealed four main categories in the data collected from online discussion forums and blogs regarding the organizational policy change. These categories included stakeholder discussion, outcomes identified by stakeholders, recommended courses of action, and communication regarding the policy change (summarized in **Table 1**). *Stakeholder discussion* was the most common category identified with a total of 168 posts, which included 35 unique themes. These posts included general opinions and views regarding the impact of the policy change and related variables, but excluded any specific outcomes or recommendations. The most common higher order sub-theme, *interacting variables,* included discussion of moderating factors or systems that could, would, or already had an influence on the outcome(s) of the policy change. The *impact of social network* was frequently cited within this sub-theme and content focused on school-based cohorts (total of 13 posts) that would be disrupted as a result of the policy change. For example, one parent shared,

> They were playing travel soccer with friends in their same grade from town and having a great time. Now knowing they will be on

[2]The data collected were publicly available and therefore, research ethics clearance was not required to conduct this study.

[3]The cross-checking process, whereby the raw data themes and clusters of sub-themes are thoroughly examined (Sparkes and Smith, 2014), was initially conducted by the first author, with additional rounds of comparison and eventual confirmation performed by the second and third authors (outlined further in the Trustworthiness and Quality section).

[4]Independent coding of the data was conducted by the lead author (familiar with relative age research) and the first round of comparison was completed with the second author (familiar with the data but not relative age research, *per se*).

[5]The second round of comparison was conducted in collaboration with the third author (familiar with relative age research).

TABLE 1 | Outline of study categories.

Category	Definition	Total number of posts
Stakeholder discussion	General opinions/views regarding the impact of the policy change and related variables	168
Outcomes identified by stakeholders	Explicit benefits or consequences of the policy change: Anticipated or presently experienced	148
Recommended courses of action	Recommendations provided by stakeholders: RAE-specific or related to the policy/organizational change	59
Communication regarding the policy change	Announcements or statements related to the unveiling/implementation of the policy change	29

> a mixed grade team, that their old team is being broken up and they will have to start all over....[6]

Additional factors/systems that were perceived to be influential included club size (e.g., implementation could be more difficult for a smaller club), grade level (e.g., "senior" year), stage of development/chronological age, cut-off dates for the education system, college recruiting practices, and state-to-state variation (e.g., availability of soccer clubs).

Other commonly identified categories falling under the category of stakeholder discussion included a recognition that the bias associated with RAEs would persist and shift to a new group of athletes. For example, one stakeholder posted that, "U.S. Soccer has not made a more level playing field for players, they just shifted who is disadvantaged." Further, it was recognized by some stakeholders that the mandate would have minimal impact with respect to talent development and identification activities. One stakeholder supported discussion with respect to a lack of impact specifically for reducing RAEs in the following post:

> The idea that organizers are unaware of this effect does not seem to be a compelling reason for such a drastic change, as the effect has been well-documented and there are very few, if any, club directors I have met who are unaware of this.

A *perceived lack of consultation or concern* exhibited by the U.S. Soccer Federation during the decision-making process for the developmental levels vs. the elite was frequently expressed, as exemplified in the following example: "It is unfortunate that US Soccer has addressed the needs of a few hundred members (at most) and not the millions that I believe they should [be] supporting." The lack of concern for stakeholder input (from any and all levels) also fell under this sub-theme. For instance, an unidentified representative at the state level posted, "It was difficult for us at the state association. We were not included in any conversations about this. We've tried to focus on how can we mitigate and make sure as few negative outcomes occur as possible." Please refer to **Table 2** for additional categories identified under stakeholder discussion.

Outcomes identified by stakeholders was the second most common category and included *explicit* benefits or consequences of the policy change, whether they were anticipated or actually (i.e., currently) being experienced by the stakeholder(s). Forty-six unique themes were identified within 148 stakeholder posts. The final tally from the data highlights that the actual *experienced impact* and *stakeholders' expectations* from implementation of the policy change were predominantly negative, outnumbering the positive outcomes 30:1 and ∼2:1, respectively. An expectation of the *loss of a season, team, or opportunity* was most common (total of 18 posts) and predominantly associated with the transition to high school.

Sport withdrawal or *dropout* was also expected (14 individual posts) as an outcome of the policy change, whether it be from sport in general or soccer specifically through transfer to a new sport. A few stakeholders also recognized the adverse impact of dropout on other aspects of the sport (e.g., loss of revenue, decreased talent pool for future advancement to higher levels). For instance, one stakeholder identified the potential impact of the policy change on future involvement in soccer:

> When they change the age brackets, how many kids stop playing? Now those kids may not grow up to be Landon Donovan, but they could grow up to be consumers of the game which drives revenue and sponsorship, they could grow up to be teachers of the game, facilitating the continued growth of the game by indoctrinating a new generation of fans. They could grow up to be board members of clubs that will shape the game for many others....

With respect to positive outcomes, there was a perceived benefit for *athlete development* mentioned by stakeholders (total of 11 posts). However, this benefit was sometimes tied to the athletes who would be relatively older (i.e., those with birthdates in January, February, and March). There was also a recognition that this mandate would benefit the national team by aligning with international competition structures. One stakeholder commented,

> It also puts our players on the same age-playing calendar as the rest of the world so they will be used to competing in the right age-group. That makes it much easier for us to scout for the national teams and find players ready to compete internationally.

Other themes identified under this category can be found in **Table 3**.

Recommended courses of action included recommendations from stakeholders which were generally directed to the U.S. Soccer Federation, but also toward other stakeholders (e.g., refusal to comply with the mandate). Some recommendations were RAE-specific, while others were related to the policy change, or organizational change in general (total of 26 unique themes in 59 stakeholder posts). Suggestions pertaining to the

[6]The latter portion of this quote was coded as a negative outcome (i.e., disruption to existing team) and was included to maintain the context of the stakeholder post.

TABLE 2 | Category: stakeholder discussion.

Theme	Number of posts	Higher order sub-theme	Number of posts
Impact of club size[a]	3	Interacting variables	47
Impact of chronological age/developmental stage	6		
Impact of school cut-off dates[b]	7		
Impact of grade level[c]	9		
Impact of collegiate system/recruiting	7		
Impact of state-to-state variation	2		
Impact of social network[d]	13		
Minimal impact of the change (i.e., for talent identification)	6	Invalid rationale for policy change	25
Change not required	5		
Persistence of RAEs due to shift in bias	14		
Strength of current system	6	Characteristics of the current system on athlete development	15
Limitation of current system	9		
International competition	5	Levels of competition	19
Talent development teams	4		
High school vs. club soccer	6		
High school vs. elite/international soccer	1		
Competitive vs. recreational soccer	1		
Tournaments	2		
Developmental levels vs. elite	13	Lack of consultation or concern	25
Developmental levels vs. sport administration	1		
National level vs. all sport stakeholders	3		
National team vs. professional soccer	1		
Stakeholder input	5		
Proper athlete development	2		
Unanswered question[e]	3	Miscellaneous	37
Explanation of age groupings	3		
Explanation of USSF decision related to RAEs[f]	2		
Change is unfair	1		
Arbitrary plan/cut-off(s)	3		
Sport as a business	6		
Participation motive[g]	8		
Long term plan	1		
Clubs need to adjust quickly	1		
Situation overblown	2		
Undetermined meaning	7		

[a] *Includes specific discussion of impact on large vs. small clubs; emphasis on the discussion aspect vs. explicit outcomes of the policy change.*
[b] *Includes specific reference to a cut-off date.*
[c] *Typically associated with the negative stakeholder expectation – loss of season, team, or opportunity; in particular, the transition to high school.*
[d] *Predominantly classmates, but also community.*
[e] *Specific questions about the policy change.*
[f] *From stakeholder perspective.*
[g] *Includes specific reasons cited that children and/or youth choose to participate in sport; sometimes highlighted in contrast with the desire to become an elite athlete.*

TABLE 3 | Category: outcomes identified by stakeholders.

Theme	Number of posts	Higher order sub-theme	Number of posts
Strengthen national team	6	Stakeholder expectations (positive)	38
Align internationally	5		
New opportunity	5		
Athlete development	11		
Decrease risk of injury	1		
Redistribute talent to enhance competition	2		
Elimination of age disadvantage[a]	2		
Provide information on RAEs/mitigate RAEs	3		
Athlete retention	2		
Independent teams[b]	1		
Cheating	1	Stakeholder expectations (negative)	77
Sport withdrawal/dropout[c]	14		
Increase RAEs	2		
Reduce access to sport	2		
Cannot play with friends/classmates	9		
Will not know teammates	1		
Detrimental to athlete development	1		
Change of team or club	6		
Athlete well-being	2		
Loss of season, team, or opportunity[d]	18		
Impact on small clubs	3		
New disadvantage	2		
Organizational chaos	2		
Confusion about age groupings	2		
Fear of playing with older or physically larger athletes	1		
Disruption to an existing team	5		
Coaches afraid to lose players[e]	1		
Impact on college recruiting/collegiate system	5		
Will not affect the growth of soccer	1	Stakeholder expectations (neutral)	1
New opportunity	1	Experienced impact (positive)	1
Teams folding/folded	2	Experienced impact (negative)	30
Small clubs could not realign teams in time	1		
Disruption to existing team	2		
Voting to fold club	1		
Unbalanced age groups	3		
Coach quit	1		
Adverse impact on coach(es)	2		
Cannot play with friends	1		
New disadvantage	1		
Athlete refusal to participate/attend practice	2		

(Continued)

TABLE 3 | Continued

Theme	Number of posts	Higher order sub-theme	Number of posts
Negative emotions (e.g., frustration, anger)	4		
Confusion about age groupings	5		
Confusion about timeline for implementation	1		
Sport withdrawal/dropout or reduced enrollment	3		
Fear of playing with older or physically larger athletes	1		
Change of club to one with more institutional support	1	Experienced impact (neutral)	1

[a] *Not specific to RAEs.*
[b] *With a focus on participation rather than elitism.*
[c] *Athletes and/or other stakeholders.*
[d] *Often related to the club vs. high school transition.*
[e] *Reason not specified.*

actual implementation of the policy change were most common with *grandparenting* being the preferred strategy (total of 11 stakeholder posts), meaning that the policy change should be implemented at the initiation levels of the sport (i.e., ages 4–6) and the cut-off date for older age groups remain unchanged. Stakeholders also recommended a longer transition time for implementation of the change, flexibility in the process/rule structure, and increased transparency at the national level.

A variety of strategies for creating athlete cohorts (i.e., *grouping strategies* such as half year age brackets and structuring by skill level) and promoting productive avenues for *organizational change* at the national level and beyond were also identified. For example, one stakeholder shared,

> I think if we worried less about checking birth certificates and focused on structuring the sporting organizations around skill levels you would find that participation would increase and would last longer particularly for those at the lower end of the skill scale and at the same time continue to provide the challenges for those at the other end of the spectrum.

Further, the stakeholder data supported a need for increased access to all levels of the sport for all socioeconomic groups. Please refer to **Table 4** for a detailed outline of themes under the category of recommended courses of action.

The final category of *communication regarding the policy change* included announcements or statements related to the unveiling of the policy change that were general in nature, but also included stakeholder posts related to any form of communication surrounding the policy change (refer to **Table 5**). Nine unique themes were identified within 29 stakeholder posts. A perceived *lack of communication* from the national level was noted in the data (total of 5 posts). For example, one stakeholder stated that, "The mandate was handed down with no parent input, and issued in a dictatorial fashion that unfortunately is a defining characteristic of U.S. Soccer." Similarly, another individual commented,

TABLE 4 | Category: recommended courses of action.

Theme	Number of posts	Higher order sub-theme	Number of posts
Longer transition time	2	Implementation	23
Flexible process	2		
Flexible rules or structure for different levels of competition	6		
Grandparenting	11		
Transparency about policy change	1		
Communicate plan of action	1		
Remove age categories	3	Grouping strategies	14
Half year age brackets	2		
Multiple age groupings	1		
Structure by skill level	4		
Remove skill categories	1		
"Loose"/flexible cut-off	2		
Undetermined meaning	1		
Focus on athlete development	3	Organizational change	17
Athlete retainment	2		
Emphasize social aspect vs. talent development	2		
Emphasize enjoyment vs. winning	1		
Educate coaches on talent selection/identification	2		
Increase access to sport for all socioeconomic groups	3		
Serve all levels of participation	1		
Improve communication/coordination	2		
Transparency at the national level	1		
Refusal to comply	1	Other	5
Change age group labels	1		
Consider best solution based on club characteristics	1		
Undetermined meaning	2		

> They have screwed up this mandate from day one, passed it in secret 8 months before they said they would, have refused to even talk to the member organizations about it and have offered zero advice in how to smoothly implement them.

Notably, two stakeholders shared club-level strategies utilized during the implementation process that could inform future policy changes of this nature. These quotes were thus coded as *communicating for the purpose of effective planning*. For instance, one commented,

TABLE 5 | Category: communication regarding the policy change.

Theme	Number of posts	Higher order sub-theme	Number of posts
Club/developmental level	6	General communication	13
National level	3		
Unknown/undetermined	4		
Club/development level	2	Communication issue	10
To the parents	1		
Lack of communication at the national level	5		
Misinformation from the national level	2		
Communicating for the purpose of effective planning[a]	2	Implementation process	6
General timing of changes	4		

[a] *Club level.*

> I can't imagine a club more prepared. They have had multiple age group parent meetings to explain the process, play dates for age group players to further assess the players and build comfort among players that might not be new faces but don't know each other well. The staff has been evaluating the players all year as well in practice and games.

Likewise, another stakeholder posted,

> At my club we got out in front of this. Met with all of our parents and held training sessions based on the birth year and the feedback we've been getting is that clearly communicating the changes, having a plan of action and getting out in front of it have aided in insuring our parents and players are less anxious about it.

Additional communication associated with the developmental level was general in nature and typically provided information regarding club policies or the timing of the implementation process.

DISCUSSION

Overall Findings

The purpose of this study was to provide a summary of online stakeholder responses (i.e., initial reactions and discussion) to the U.S. Soccer Federation's decision to change the age group cut-off date from August 1st to January 1st, as voiced through social media and website blogs. The immediate impact was assessed to the extent possible through online mediums, and attention was given to stakeholders' perceptions of the manner in which the decision was framed and publicly communicated. Four categories emerged from the data, which included stakeholder discussion, outcomes identified by stakeholders, recommended courses of action, and communication regarding the policy change. In general, the actions of the U.S. Soccer Federation and related outcomes were negatively perceived by stakeholders.

The *impact of social network* developed through the education system was frequently cited and indeed, school-related friendships have been found to have a positive influence on athlete engagement (e.g., Fraser-Thomas et al., 2008). Friends were cited as the most common participation motive in the current study, followed by fun/enjoyment of the game. An emphasis on these aspects of participation is recommended during the early years of participation (e.g., 12 years of age and younger) and is often contrasted with a focus on elitism at young ages (see Côté and Abernethy, 2012 for further discussion). Thus, it is possible that the U.S. Soccer Federation may have contributed to a reduction in participation through an increased rate of dropout as a result of this policy change. The potential for this to occur was supported by qualitative data collected in this analysis (i.e., dropout categories were identified under the sub-themes of *experienced impact* and *stakeholder expectations*). A detailed participation analysis is not currently available in the published literature and this assertion is currently speculative. A decline in U.S. soccer participation coinciding with implementation of the policy change has been reported by various sources (e.g., Sports Fitness Industry Association, 2018; Lange, 2020), but needs to be confirmed using longitudinal data. Further, a detailed examination of the underlying contributors to this trend may be informative for the U.S. Soccer Federation and other national level sport governing bodies who may be contemplating a similar policy change, as increased dropout rates could theoretically affect the talent pool available for future advancement to international levels of competition.

"*Grandparenting*," whereby changes are implemented gradually beginning in the initiation years of participation (i.e., ages 4–6), may have been a feasible solution for consideration and was recommended by multiple stakeholders. However, the data suggest this option was not made available to local clubs and opportunities for stakeholder input were limited. Further, a perceived lack of "transparency" and *lack of concern/consultation* for the developmental levels (vs. the elite) surfaced in the content of stakeholder posts; this occurred despite the recognition by some stakeholders that the change would indeed provide benefits at the highest levels of international competition.

Relative Age Considerations

With respect to RAEs, it was recognized by several stakeholders that the policy change would not resolve the inequitable selections and provision of opportunities afforded to those who are relatively older (e.g., Cobley et al., 2009), and was thus not an appropriate rationale for this policy change. The assertion that relative age bias would simply shift to a new group of athletes is supported by previous research. Helsen et al. (2000) analyzed birthdate distributions for national youth league players between the ages of 10 and 18 years, after the Belgian Soccer Federation implemented a similar cut-off date change. Among 10 to 16-year-olds, the athletes born in the early part of the *new* selection year (i.e., those born in January through March) were more likely to be identified as talented compared to those born later (i.e., August through October) and who had previously been advantaged only 1 year earlier. The researchers attributed this shift in selection advantages to athletes' physical size rather than differences in their skill or talent levels, as supported by a previous examination of Belgian youth soccer players (Helsen et al., 1998).

Several of the recommendations proposed by stakeholders were aligned with relative age literature, showing an awareness of RAEs. However, there continues to be a lack of appropriate, interventive action at the developmental levels of sport (Wattie et al., 2015; Mann and van Ginneken, 2017). For instance, smaller age brackets (Boucher and Halliwell, 1991) and removal of skill categories prior to the completion of maturation (Baker et al., 2010) have been proposed in previous work. This observation also indirectly supports the notion that increasing general awareness of RAEs is not enough to mitigate their impact (see Helsen et al., 2012 for further discussion).

Recommendations for Future Policy Changes

While a change to an annual age-group cut-off date is a rare event, the findings of this analysis can inform other types of organizational change in sport at various levels of participation (e.g., from the grassroots level to talent development academies). Further, the findings of this study add to the limited body of research examining the implementation of organizational change at the youth sport level and provide support for recommendations in previous literature.

Legg et al. (2016) examined the impact of a province-wide change initiated by *Ontario Soccer* (previously known as the *Ontario Soccer Association*), aimed at improving *Long-Term Player Development* in Ontario, Canada. A case study approach was utilized with study participants recruited from one of four groups: staff members from Ontario Soccer, board members at two local-level soccer clubs, coaches, and parents. Factors that both aided and constrained the change were identified; and similarities to the present analysis exist. First, the importance of formal communication from the sport governing body was highlighted. Qualitative data in this study suggest communication from the U.S. Soccer Federation was limited. However, this organization should have been the "dominant voice" in the process to both educate and communicate the new procedures to be followed (Danylchuk et al., 2015; Legg et al., 2016). Misinformation from the national level was also reported. Specifically, unreliable information was cited with respect to cut-off dates in other countries, along with errors in the new age divisions outlined prior to implementation. The importance of communication is also supported by anecdotal reports from representatives in two unnamed clubs in this study; specifically, holding meetings with parents and communicating a plan of action were perceived to be effective in easing concerns about the policy change. However, a lack of information at the club/developmental level was also reported, suggesting accurate, consistent (i.e., from all levels of the sport), and timely information was needed for all stakeholders (e.g., athletes, parents, coaches) to facilitate implementation.

The second recommendation that can be supported based on the current data is the endorsement of stakeholder involvement from all levels in the decision-making process. For example, suggestions for grandparenting or a "phase-in approach" were made and may have been met with a greater degree of acceptance of the mandate by stakeholders at developmental levels (Legg et al., 2016). McVea and Freeman (2015) argued for the importance of stakeholder "relationships" (as opposed to inferior "roles") in creating value during organizational decision-making, suggesting stakeholders have an important role to play in the success of any organization in benefitting those affected by organizational activities. When conflicts arise (as they often do), organizational leaders must adapt to create as much value as possible for these stakeholders (Freeman et al., 2010). Acknowledging that an examination of U.S. Soccer's specific efforts to gain stakeholder input was beyond the scope of this study, the perceived *lack of consultation or concern* for the developmental levels inherent in the current data may be concerning. Stakeholders should be consulted and involved in strategic planning, actively engaged in achieving outcomes, and well-informed regarding organizational activities (e.g., Australian Sports Commission, 2012).

Strengths and Limitations

Obtaining the current data from social media and website blogs provided a novel collection method that may avoid or minimize the responder bias that might be present in a more traditional research setting. Further, social media and other modes of internet communication provide more options for sharing opinions (Picard, 2015), permitting the sampling of a widespread and diverse population (i.e., the U.S. Soccer community across various levels of participation and different regions of the country). However, it is acknowledged that this analysis is limited to stakeholders who chose to express their opinions in online forums and thus, may not have been fully representative of all stakeholders impacted by the change (e.g., the youngest U.S. soccer participants). These online data may also be limited by the fluidity of stakeholder opinions. For example, some posts had a negative emotional tone and may have been written in the "heat of the moment." Ideally, follow-up assessments would be conducted after a period of time had passed. This was not feasible in the design of the current study. Furthermore, elements of social media (e.g., anonymity) tend to lend themselves to "belligerent venting of anger" (Picard, 2015, p. 38) and individuals tend to be drawn to negative content (Acerbi, 2019). This may account for the high number of negative views/opinions (vs. positive content) that was noted in the collected data.

The use of qualitative (hierarchical) content analysis provided a comprehensive, descriptive summary of the data that can inform future policy change. However, this method of analysis was limited in this study because in most cases, it was not possible to identify *who* made the post in the online forum. For instance, it would be informative to know whether the stakeholder was an athlete, parent, coach, or administrator, along with relevant demographic information (e.g., age, gender, level of competition, degree/length of involvement in the sport, volunteer or paid coach/administrator). This information could provide insight into how organizational change(s) could be tailored at various levels of participation for greater effectiveness and ease of implementation.

Additional limitations associated with content analysis include the possibility for tagging of raw data themes to separate an important section of text from the context in which it was delivered by the stakeholder (Sparkes and Smith, 2014). Care was taken during the coding process to minimize this by isolating distinct sections within a stakeholder post in proximity to the rest of the passage (i.e., stakeholder posts were divided into multiple sections, and labeled a, b, c, as required). Homogeneity within themes and sub-themes were carefully reviewed following this process. The descriptive statistics utilized may give the impression that "more is better" (Sparkes and Smith, 2014) and it is acknowledged that this may or may not be the case. Highly relevant themes emerged in smaller numbers in this study (e.g., communication at the club level) and these were discussed accordingly in the paper. Along with the aforementioned limitations, this study is limited by the researcher bias that can occur in any type of qualitative analysis. Attempts were made to minimize this potential source of bias by conducting two rounds of comparison (i.e., between the first and second/third authors). This process included critical dialogue between the authors.

Future Directions

In this study, the content of the qualitative data suggested that the majority of stakeholders had recently become aware of the policy change at the time of posting on the social media/website blog or were currently in the initial stages of implementation. Thus, post-implementation outcomes and follow-up would be valuable. Further qualitative analysis at various levels of U.S. soccer would be informative. For instance, interviews with U.S. Soccer Federation representatives might enhance understanding of the contributing factors influencing the decision process for this mandate. Case studies with athletes, parents, coaches, and administrators would be helpful and could provide additional evidence to support or refute the findings of this study. This could also include analysis of formal press releases from member organizations and/or club-level policy changes occurring subsequent to the U.S. Soccer mandate. Quantitative analyses of dropout subsequent to implementation of the policy change, along with examination of associated factors (e.g., loss of revenue, reduced volunteerism) would be informative for sport governing bodies including the U.S. Soccer Federation, but also for local and regional level sport organizations due to the potential impact of sport withdrawal at all levels of participation.

Conclusions

This study examined the online stakeholder response to the U.S. Soccer Federation's decision to change the organizational cut-off date to align with international standards and "lessen" RAEs in the sport. Stakeholder reactions were generally negative, and resistance to the change may have been reduced through better communication from the national level and opportunities for stakeholder involvement. Further, post-implementation analyses would be valuable using a variety of methodological approaches.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JD, SH, and LC designed the study. SS collected and cleaned the data. KS coded the data (with assistance from LC and SS), summarized the results, and drafted the manuscript. All authors participated in the editing process and have approved the final version of the manuscript.

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REFERENCES

Acerbi, A. (2019). Cognitive attraction and online misinformation. *Palgrave Commun.* 5:15. doi: 10.1057/s41599-019-0224-y

Australian Sports Commission (2012). *Sports Governance Principles*. Available online at: http://www.icsspe.org/system/files/Australian%20Sports%20Commission%20-%20Sports%20Governance%20Principles.pdf (accessed January 30, 2021).

Baker, J., Janning, C., Wong, H., Cobley, S., and Schorer, J. (2014). Variations in relative age effects in individual sports: skiing, figure skating and gymnastics. *Eur. J. Sport Sci.* 14, S183–S190. doi: 10.1080/17461391.2012.671369

Baker, J., Schorer, J., and Cobley, S. (2010). Relative age effects: an inevitable consequence of elite sport? *Sportwissenschaft* 1:26–30. doi: 10.1007/s12662-009-0095-2

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Bedard, K., and Dhuey, E. (2006). The persistence of early childhood maturity: international evidence of long-run age effects. *Q. J. Econ.* 121, 1437–1472. doi: 10.1162/qjec.121.4.1437

Boucher, J., and Halliwell, W. (1991). The novem system: a practical solution to age grouping. *Can. Assoc. Health Phys. Educ. Recreat.* 57, 16–20.

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Côté, J., and Abernethy, B. (2012). "A developmental approach to sport expertise," in *The Oxford Handbook of Sport and Performance Psychology,* ed S. M. Murphy (New York, NY: Oxford University Press), 435–447.

Danylchuk, K., Snelgrove, R., and Wood, L. (2015). Managing women's participation in golf: a case study of organizational change. *Leisure/Loisir* 39, 61–80. doi: 10.1080/14927713.2015.1074394

Dhuey, E., and Lipscomb, S. (2008). What makes a leader? Relative age and high school leadership. *Econ. Educ. Rev.* 27, 173–183. doi: 10.1016/j.econedurev.2006.08.005

Fraser-Thomas, J., Côté, J., and Deakin, J. (2008). Examining adolescent sport dropout and prolonged engagement from a developmental perspective. *J. Appl. Sport Psychol.* 20, 318–333. doi: 10.1080/10413200802163549

Freeman, R. E., Harrison, J. S., Wicks, A. C., Parmar, B., and de Colle, S. (2010). *The Problems That Stakeholder Theory Tries to Solve. Stakeholder Theory. The State of the Art*. Cambridge, UK: Cambridge University Press, 3–29.

Gladwell, M. (2008). *Outliers: The Story of Success*. New York, NY: Penguin Group Inc.

Helsen, W. F., Baker, J., Michiels, S., Schorer, J., Van Winckel, J., and Williams, M. (2012). The relative age effect in European professional soccer: did ten years of research make any difference? *J. Sports Sci*. 30, 1665–1671. doi: 10.1080/02640414.2012.721929

Helsen, W. F., Baker, J., Schorer, J., Steingröver, C., Wattie, N., and Starkes, J. L. (2016). Relative age effects in a cognitive task: a case study of youth chess. *High Ability Stud*. 27, 211–221. doi: 10.1080/13598139.2016.1242063

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (1998). The influence of relative age on success and dropout in male soccer players. *Am. J. Hum. Biol*. 10, 791–798. doi: 10.1002/(SICI)1520-6300(1998)10:6<791::AID-AJHB10>3.0.CO;2-1

Helsen, W. F., Starkes, J. L., and Van Winckel, J. (2000). Effect of a change in selection year on success in male soccer players. *Am. J. Hum. Biol*. 12, 729–735. doi: 10.1002/1520-6300(200011/12)12:6<729::AID-AJHB2>3.0.CO;2-7

Lange, D. (2020). *Share of Participants in Kids' Soccer in the U.S. 2018*. Available online at: https://www.statista.com/statistics/982274/participation-kids-soccer/ (accessed November 27, 2020).

Legg, J., Snelgrove, R., and Wood, L. (2016). Modifying tradition: examining organizational change in youth sport. *J. Sport Manag*. 30, 369–381. doi: 10.1123/jsm.2015-0075

Lemez, S., Baker, J., Horton, S., Wattie, N., and Weir, P. (2014). Examining the relationship between relative age, competition level, and dropout rates in male youth ice-hockey players. *Scand. J. Med. Sci. Sports* 24, 935–942. doi: 10.1111/sms.12127

MacDonald, D., and Baker, J. (2013). "Circumstantial development: birthdate and birthplace effects on athlete development," in *Conditions of Children's Talent Development in Sport*, eds J. Côté and R. Lidor (Morgantown, WV: Fitness Information Technology), 197–208.

Malina, R. M., Bouchard, C., and Bar-Or, O. (2004). "Maturity-associated variation in growth and performance," in *Growth, Maturation, and Physical Activity*, eds R. M. Malina, C. Bouchard, and O. Bar-Or (Champaign, IL: Human Kinetics), 337–365.

Mann, D. L., and van Ginneken, P. J. M. A. (2017). Age-ordered shirt numbering reduces selection bias associated with the relative age effect. *J. Sports Sci*. 35, 784–790. doi: 10.1080/02640414.2016.1189588

McVea, J. F., and Freeman, R. E. (2015). A names-and-faces approach to stakeholder management. How focusing on stakeholders as individuals can bring ethics and entrepreneurial strategy together. *J Manag. Inquiry* 14, 57–69. doi: 10.1177/1056492604270799

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev*. 21, 147–167. doi: 10.1006/drev.2000.0516

Picard, R. G. (2015). The humanisation of media? Social media and the reformation of communication. *Commun Res. Pract*. 1, 32–41. doi: 10.1080/22041451.2015.1042421

Romann, M., and Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS ONE* 10:e0122988. doi: 10.1371/journal.pone.0122988

Sandelowski, M. (2000). Whatever happened to qualitative description? *Res. Nurs. Health* 23, 334–340.doi: 10.1002/1098-240X(200008)23:4<334::AID-NUR9>3.0.CO;2-G

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med*. 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Sparkes, A. C., and Smith, B. (2014). *Qualitative Research Methods in Sport, Exercise and Health. From Process to Product*. New York, NY: Routledge.

Sports and Fitness Industry Association (2018). *Soccer Participation in the United States*. Available online at: https://sfia.medium.com/soccer-participation-in-the-united-states-92f8393f6469 (accessed November 27, 2020).

U.S. Soccer (2017). *Five Things to Know About Birth Year Registration*. Available online at: https://www.ussoccer.com/stories/2017/08/five-things-to-know-about-birth-year-registration (accessed February 11, 2020).

U.S. Youth Soccer (2016). *US Youth Soccer Statement on U.S. Soccer's Birth-Year Registration Mandate*. Available online at: http://www.usyouthsoccer.org/us_youth_soccer_statement_on_us_soccer%E2%80%99s_birth-year_registration_mandate/ (accessed October 12, 2016).

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci*. 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med*. 45, 83–94. doi: 10.1007/s40279-014-0248-9

Woitalla, M. (2015). *Youth Leaders React to Change in Soccer's Registration Cut-Off Date*. Available online at: http://www.socceramerica.com/article/65329/youth-leaders-react-to-change-to-soccers-registra.html (accessed November 21, 2020).

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Handedness and Relative Age in International Elite Interactive Individual Sports Revisited

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Relative age effects (RAE) describe the unintended side effect of annual age grouping such that athletes born close to a specific cutoff date are more likely to be associated with attaining higher performance status than athletes born later. One factor suggested to override the RAE is handedness. Given the left-handers' rarity and their proposed performance advantage in interactive sports, left-handedness may be associated with a lower likelihood of suffering from selection inequalities like RAE in those sports compared with right-handedness. Here, in a two-study approach, we tested that hypothesis by examining male and female athletes from various interactive individual sports sampled over a 10-year period from 2007 to 2016. Study 1 investigated distributions of birth and handedness of senior athletes listed in the top 200 of year-end world rankings in table tennis, tennis, squash, and fencing (épée, foil, and saber). Study 2 followed a similar design but focused on junior athletes in the fencing disciplines and tennis. Unlike the above prediction, in both studies, birth distribution was not found to be reliably associated with handedness in any of the sports or disciplines considered. Left-handers were consistently overrepresented in épée, foil, and table tennis, occasionally in saber and tennis, and not at all in squash. Birth frequencies decreased from quartile Q1 (January to March) to Q4 in almost any sporting domain at the junior level, whereas such trend was rarely found at the senior level. In conclusion, while providing novel insight on the role handedness may play at the junior level, our findings do not support the hypothesis that left-handedness helps override birth-related inequalities in high sporting achievement in elite interactive individual sports.

Keywords: racket sports, birthdate, laterality, season of birth, birthday, talent development, youth

INTRODUCTION

Once you are born at the right time, you have it in your own hands to reach elite levels in interactive individual sports, or so it seems (Deaner et al., 2013). However, one's own birthdate and laterality independently seem to be associated with different probabilities to become an elite athlete (Loffing et al., 2010; Barrenetxea-Garcia et al., 2019). Much less is known about the interaction of these two moderators (Wattie et al., 2015). Here, we revisit the association of relative age and handedness with achieving world-class performances in interactive sports in adult and junior athletes.

In many interactive (as well as others) sports, sport policy makers decided to use a cutoff date like the first of January to reduce injustices in competitions (Dixon et al., 2020). While this was well intended, it still resulted in relative age effects (RAE), in which athletes born closer to the cutoff date had a higher probability to make it than others that were born later in the year. The effect was reported in a wide range of interactive individual sports like tennis (Edgar and O'Donoghue, 2005; O'Donoghue, 2009), table tennis (Faber et al., 2020a), and fencing (Romann and Fuchslocher, 2014; Romann et al., 2018; Switzerland), but not in English squash (Kelly et al., 2020a), and was generally stronger in male than in female athletes (Smith et al., 2018). In sports, the RAE phenomenon increases with age, and it reaches its peak during adolescence (15–18 years) and reduces at the senior level (Cobley et al., 2009). Moreover, according to the competition hypothesis, the likelihood for and the size of RAE increase with increasing competition for the limited resources (e.g., squad membership) in a sport (Sherar et al., 2007). Musch and Grondin (2001) considered competition a necessary condition for RAE to occur at all.

After 30 years of research on the topic, finally, a first theoretical model was introduced by Wattie et al. (2015). On the basis of the work by Bronfenbrenner and colleagues (Bronfenbrenner and Ceci, 1994; Bronfenbrenner, 2000), Wattie and colleagues presented a developmental model of RAE. The idea of Newell's (1986) constraint-based developmental model results in a framework that differentiates influential variables in three different constraints: environmental, task, and individual constraints. As environmental constraints, the authors summarize variables like policies, social norms, quality of sport development programs, and family influences (Wattie et al., 2007; Cobley et al., 2008; Addona and Yates, 2010; Hancock et al., 2013; Schorer et al., 2013). As task constraints, they introduce the type of sport and level of competition (Schorer et al., 2009; Smith et al., 2018; Faber et al., 2020a). As individual constraints, variables like sex (Smith et al., 2018) or laterality (Loffing et al., 2010; Barrenetxea-Garcia et al., 2019) are considered. While some constraints have been given a considerable amount of attention, little is known about the interaction of laterality and RAE (Wattie et al., 2015).

The rarity of left- compared with right-handers is suggested to provide the former with a performance advantage in a variety of interactive sports (for reviews, e.g., see Grouios, 2004; Loffing and Hagemann, 2012, 2016). Athletes performing a sport-specific task with the left hand (e.g., holding a racket or weapon) have consistently been found disproportionally more often compared with normal population estimates of left-handedness at the top level of interactive individual sports like table tennis (Malagoli Lanzoni et al., 2013; Loffing, 2017) and the fencing disciplines of foil and épée, but not saber (Raymond et al., 1996; Harris, 2016). These findings suggest that handedness is not a neutral trait with regard to performance in these sports, especially not in male competition where a left-hander overrepresentation was found more pronounced compared with female competition (Raymond et al., 1996; Breznik, 2013; Loffing, 2017). As a caveat to this suggestion, however, left-handers were only occasionally found overrepresented in professional tennis (Holtzen, 2000; Loffing et al., 2012) and not at all in squash (Loffing, 2017), which indicates that a left-hander advantage may be particularly evident in interactive sports that are characterized by high spatiotemporal pressure (e.g., table tennis, fencing) as opposed to relatively slower interactive sports (e.g., tennis, squash) (Loffing, 2017).

In view of the performance benefits ascribed to left-handedness in interactive sports, it has been suggested that left-handedness may be associated with reduced likelihood of suffering from selection inequalities like RAE (Wattie et al., 2015). Evidence in at least partial support of this notion can primarily be inferred from data on interactive team sports like handball (Schorer et al., 2009), cricket (Connor et al., 2019), baseball (Zhang et al., 2018), and water polo (Barrenetxea-Garcia et al., 2019). Birth distribution was found to be heavily skewed toward quartile 1 (January–March) in right- but not left-handed backcourt players from the German first handball league for the seasons 2004/2005–2007/2008 (Schorer et al., 2009). Published research examining the possible link between RAE and handedness in individual interactive sports, however, is surprisingly scarce. The only study available to date investigated RAE and handedness in a sample of 1,027 male professional senior tennis players (13.44% left-handed) listed in the top 500 of year-end world rankings in 2000–2006 (Loffing et al., 2010). Birth distribution was skewed toward quartiles 1 (January–March) and 2 (April–June) in right- but not in left-handed players. The effect of left-handed players being born more often in the second (52.9%) than in the first half of the year and a reversed pattern of birth frequencies in right-handed players (first half: 57.59%), however, was very small [$w = 0.07$, 90% CI (0.02, 0.12)]. Overall, given the paucity of substantial evidence in favor of a reliable association between handedness and RAE, it remains open whether laterality, and handedness in particular, is not only a statistical but also a practically meaningful factor for explaining the RAE phenomenon in sports (Wattie et al., 2015).

The overarching aim of this work was to close this research gap. In a two-study approach, we first investigated the association of RAE and handedness in varying interactive sports at the senior level. In a second study, the association was tested further in junior athletes of interactive sports. Both age groups were included given the clear indication that the extent of RAE varies with age (Cobley et al., 2009). Overall, the two studies were intended to provide us with a clearer picture of the potential association between relative age and handedness.

STUDY 1: RELATIVE AGE EFFECTS AND HANDEDNESS IN WORLD-CLASS SENIOR ATHLETES

Here, we sought to test the hypothesis that top-ranked athletes' left-handedness is associated with lower likelihood of suffering the commonly observed RAE phenomenon as compared with right-handedness in individual interactive sports at the senior level (cf. Schorer et al., 2009; Loffing et al., 2010; Barrenetxea-Garcia et al., 2019). If so, birth distribution should be skewed more heavily toward the "classical" RAE

TABLE 1 | Web sources used for the retrieval of year-end world rankings in 2007 to 2016 and total number of unique female and male senior (study 1) and junior (study 2) athletes.

Age group	Sport (discipline)	N_{female}	N_{male}	Source
Senior (study 1)	Fencing (épée)	629	652	www.fie.org (all years)
	Fencing (foil)	628	637	
	Fencing (saber)	608	672	
	Table tennis	507	435	www.ittf.com (all years)
	Tennis	497	458	www.wtatennis.com (all years; females), www.atptour.com (all years; males)
	Squash	546	515	www.squashinfo.com (2007–2015), www.psaworldtour.com (2016)
Junior (study 2)	Fencing (épée)	984	1,131	www.fie.org (all years)
	Fencing (foil)	935	1,024	
	Fencing (saber)	923	1,035	
	Tennis	572	650	www.itftennis.com (all years; ITF junior rankings)

In racket sports, all year-end rankings were obtained for end of December. In fencing, all rankings are season-end rankings and were assigned to the year a season ended for analyses (e.g., rankings for the season 2007/2008 were assigned to the year 2008).

pattern in right-handed as opposed to left-handed athletes. To enhance the generalizability of the findings across different individual interactive sports where left-handers are suggested to be advantaged (e.g., table tennis, fencing) or rather not (e.g., squash, tennis) (Raymond et al., 1996; Loffing, 2017) as well as to account for potential temporal variability in the RAE phenomenon (O'Donoghue, 2009; Schorer et al., 2020), we considered data on 10 year-end world rankings from 2007 to 2016 in six different interactive sports or sporting disciplines [fencing (épée, foil, saber), table tennis, tennis, squash].

MATERIALS AND METHODS

Data Retrieval

The lists of senior female and male top 200 athletes in various sports' year-end world rankings from 2007 to 2016 were manually retrieved from the sports' official websites (**Table 1**). Athletes' task-specific handedness (i.e., hand used for holding a fencing weapon or a racket) was assessed from the same websites or determined based on additional searches on the web such as pictures or videos showing an athlete in action. The full raw dataset underlying this study is made available in the accompanying **Supplementary Material**.

Data Analyses

In accordance with the primary study aim, data analyses were conducted separately by sex, sport, and discipline (fencing only). Inferential statistics were calculated on the frequencies of unique athletes ($N = 6,784$ in total) collapsed across the 10-year ranking period to prevent that the same individuals who were listed more than once in year-end world rankings were counted more than once. Indeed, across sports, the majority of athletes was listed twice or more among the top 200 year-end world rankings (57.3% in male saber to 79.9% in male tennis), with a small portion of athletes even listed in all year-end rankings (3.1% in male saber to 11.7% in male table tennis; see **Supplementary Table 1** for a complete overview).

The reduced dataset on all unique athletes listed in the respective sports' rankings is also made available as **Supplementary Material** (see also **Table 1**).

To test for left-hander overrepresentation, the observed frequencies for left- and right-handedness were compared against expected normal population left-hander frequencies of 7.7% (females) and 10.3% (males) (Raymond et al., 1996), respectively, using chi-square goodness-of-fit tests. To test for RAE in birth distribution, athletes' birth months were first categorized into birth quartiles based on a universally assumed cutoff date of January 1st in all sports under consideration [i.e., quartile 1 (Q1) = January–March, Q2 = April–June, Q3 = July–September, Q4 = October–December]. In line with the traditional analytic approach in RAE research, chi-square goodness-of-fit tests were then conducted to compare observed frequencies against the assumption of uniform distribution. In addition, odds ratios (OR) were calculated based on the observed absolute frequencies for athletes born in Q1 relative to athletes born in Q4: $OR = Q_1 / Q_4$. Descriptively, $OR > 1$ indicates higher chances of athletes being born in Q1 than Q4, $OR < 1$ indicates the opposite, and $OR = 1$ reflects equal chances. The limits of the 95% confidence intervals (CI) on ORs were calculated as: $\exp[\ln(OR) \pm 1.96 * (sqrt((1/Q_1) + (1/Q_4)))]$, where exp = natural exponential function, ln = natural logarithm, and sqrt = square root.

Finally, 2 (handedness) × 4 (birth quartile) chi-square tests of independence were run to test whether birth distribution is skewed more heavily toward the "classical" RAE pattern in right- compared with left-handed athletes. In addition, ORs were also calculated based on the observed absolute frequencies as the ratio of right-handed athletes being born in Q1 as opposed to Q4 relative to left-handed athletes being born in Q1 as opposed to Q4: $OR = (RH_{Q1}/RH_{Q4})/(LH_{Q1}/LH_{Q4})$. Thus, ORs reflect the chances of right-handers being born in the first vs. the fourth quartile relative to left-handers being born in the first vs. the fourth quartile. Descriptively, $OR > 1$ indicates higher chances in right- than left-handers, $OR < 1$ indicates the opposite, and $OR = 1$ reflects equal chances. The limits of the corresponding 95% CI were calculated as: $\exp[\ln(OR) \pm 1.96 * (sqrt((1/RH_{Q1}) + (1/RH_{Q4}) + (1/LH_{Q1}) + (1/LH_{Q4})))]$.

For all inferential analyses, α was set at 0.05 and Cohen's (1988) w [i.e., $sqrt(\chi^2/N)$], where N = total number of cases considered in a particular analysis) was calculated as a standardized effect size measure for chi-square analyses. For each effect size w, the 90% confidence interval was calculated based on the noncentral chi-square files provided by Michael Smithson (http://www.michaelsmithson.online/stats/CIstuff/CI.html)[1].

[1]The SPSS-script provided by Michael Smithson allows calculation of the confidence intervals on the noncentrality parameter lambda (λ_{low}, λ_{upp}) of the noncentral chi-square distribution. Based on these calculations, the lower (w_{low}) and upper (w_{upp}) bounds of the confidence interval on Cohen's w are obtained *via* $w_{low} = sqrt[\lambda_{low}/N]$ and $w_{upp} = sqrt[\lambda_{upp}/N]$, respectively.

RESULTS AND DISCUSSION

Handedness Distribution

In line with previous research (Raymond et al., 1996; Loffing, 2017), the number of left-handed athletes observed in the 10-year period was higher than expected from the normal population estimate, especially in the high time pressure sporting domains of foil (females: 22.77%, males: 25.75%), épée (females: 16.85%, males: 20.86%), and table tennis (females: 18.64%, males: 25.18%; **Table 2**). In these disciplines, effect size point estimates and *lower* limits of associated 90% CIs are located in Cohen's (1988) conventional area of medium ($w = 0.3$–0.5) to large effects ($w \geq 0.5$), pointing toward a substantial advantage for left-handed athletes. Left-handedness was not more prevalent and thus likely not substantially beneficial to performance in squash (females: 6.77%, males: 8.97%) and tennis (females: 8.85%, males: 12.66%). In saber, an at least statistically significant overrepresentation was evident in female (11.68%) but not in male competition (12.50%), thus indicating no systematic left-hander overrepresentation in this discipline along with small effect sizes as opposed to the other two fencing disciplines.

In addition to the former findings on data collapsed across the 10-year ranking period, **Figure 1** gives an overview of the temporal variability in year-end rankings' left-hander frequencies (cf. Goldstein and Young, 1996; Loffing et al., 2012; Loffing and Hagemann, 2015). Accordingly, in female and male competition, the proportion of left-handedness was relatively stable across years. Importantly, the temporal stability found here should not be interpreted as evidence for temporal stability of left-hander frequencies *per se*. Instead, stability might result from the relatively narrow 10-year window across which frequencies were considered and the large proportion of athletes listed twice or more among the top performers within that period (see **Supplementary Table 1**). Inspection of broader time windows, for example, in tennis (4 decades: Loffing et al., 2012), boxing (9 decades: Loffing and Hagemann, 2015), or baseball (11 decades: Goldstein and Young, 1996), revealed considerable temporal variation in left-hander frequencies.

TABLE 2 | Absolute frequencies and results from chi-square goodness-of-fit tests related to handedness in senior athletes (study 1).

Sex	Sport (discipline)	Handedness					
		L	R	N/A	χ^2	*p*	*w* and 90% CI
Female	Fencing (épée)	106	523	0	74.13	<0.001	0.34 (0.28, 0.41)
	Fencing (foil)	143	485	0	200.69	<0.001	0.57 (0.5, 0.63)
	Fencing (saber)	71	537	0	13.54	<0.001	0.15 (0.08, 0.22)
	Table tennis	88	384	35	79.54	<0.001	0.41 (0.33, 0.49)
	Tennis	44	453	0	0.93	0.335	0.04 (0, 0.12)
	Squash	36	496	14	0.65	0.419	0.03 (0, 0.11)
Male	Fencing (épée)	136	516	0	78.68	<0.001	0.35 (0.28, 0.41)
	Fencing (foil)	164	473	0	164.48	<0.001	0.51 (0.44, 0.57)
	Fencing (saber)	84	588	0	3.52	0.061	0.07 (0, 0.14)
	Table tennis	107	318	10	101.80	<0.001	0.49 (0.41, 0.57)
	Tennis	58	400	0	2.77	0.096	0.08 (0, 0.15)
	Squash	46	467	2	0.99	0.321	0.04 (0, 0.12)

L, left-handed; R, right-handed; N/A, handedness not available; w, standardized Cohen's (1988) effect size. df = 1 for all comparisons (see main text for details).

Birthdate Distribution

Irrespective of handedness, the "classical" RAE distributional pattern of birth frequencies was not systematically skewed toward quartiles 1 (January–March) and 2 (April–June) across sports. A RAE-like distribution of birth quartile frequencies was only indicated in female table tennis and saber as well as male tennis, with point estimates for Cohen's (1988) *w* and 90% CI *upper* limits below the conventional limit for a medium effect (**Table 3**). Likewise, odds ratios obtained from the comparison of frequencies observed for Q1 vs. Q4 provide indication for small RAE particularly in female table tennis ($OR = 1.71$) and male tennis ($OR = 1.52$; see **Table 3**). Given these findings, birth

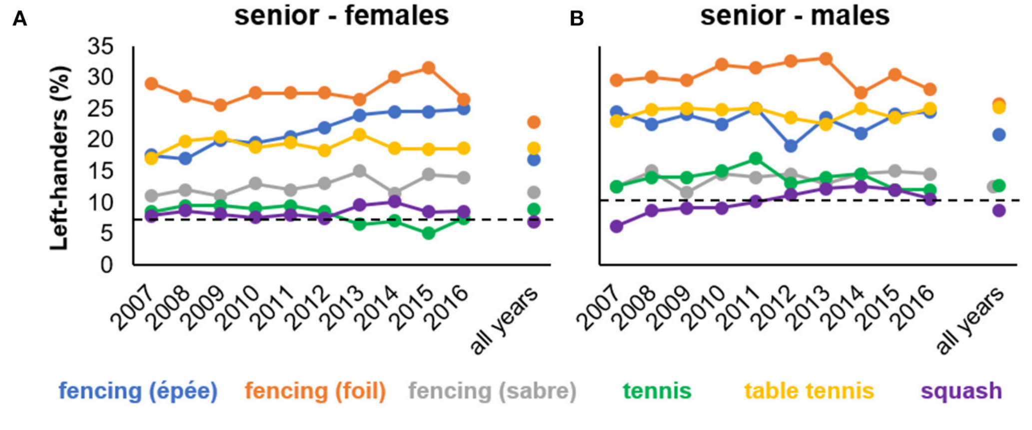

FIGURE 1 | Percentages of left-handed athletes for each year-end ranking and collapsed across all years listed for a particular sport separately for **(A)** female and **(B)** male senior competition (study 1). Horizontal dashed lines represent reference values for normal population estimates of left-handedness in females (7.7%) and males (10.3%), respectively (Raymond et al., 1996).

TABLE 3 | Absolute frequencies, results from chi-square goodness-of-fit tests, and odds ratios related to relative age in senior athletes (study 1).

Sex	Sport (discipline)	Relative age								
		Q1	Q2	Q3	Q4	N/A	χ^2	*p*	*w* and 90% CI	OR and 95% CI
Female	Fencing (épée)	166	170	166	127	0	7.83	0.050	0.11 (0, 0.17)	1.31 (1.04, 1.65)
	Fencing (foil)	180	165	143	140	0	6.87	0.076	0.10 (0, 0.16)	1.29 (1.03, 1.60)
	Fencing (saber)	182	140	145	141	0	7.99	0.046	0.11 (0.01, 0.17)	1.29 (1.04, 1.61)
	Table tennis	159	117	131	93	7	18.24	<0.001	0.19 (0.1, 0.26)	1.71 (1.32, 2.21)
	Tennis	143	132	115	107	0	6.40	0.094	0.11 (0, 0.17)	1.34 (1.04, 1.72)
	Squash	145	125	133	129	14	1.68	0.640	0.06 (0, 0.1)	1.12 (0.89, 1.42)
Male	Fencing (épée)	182	151	163	155	1	3.49	0.321	0.07 (0, 0.12)	1.17 (0.95, 1.45)
	Fencing (foil)	159	178	147	153	0	3.40	0.335	0.07 (0, 0.12)	1.04 (0.83, 1.30)
	Fencing (saber)	178	164	192	137	1	9.85	0.020	0.12 (0.04, 0.17)	1.3 (1.04, 1.62)
	Table tennis	122	100	113	97	3	3.76	0.289	0.09 (0, 0.15)	1.26 (0.96, 1.64)
	Tennis	128	133	113	84	0	12.72	0.005	0.17 (0.07, 0.23)	1.52 (1.16, 2.01)
	Squash	141	124	124	125	1	1.63	0.653	0.06 (0, 0.1)	1.13 (0.89, 1.44)

Q1 … Q4, birth quartile 1 (January–March) … birth quartile 4 (October–December); N/A, birthdate not available; w, standardized Cohen's (1988) effect size; OR, odds ratio based on frequencies observed for Q1 and Q4 (see main text for details). df = 3 for all chi-square comparisons.

TABLE 4 | Absolute frequencies, results from chi-square tests of independence between handedness and relative age, and odds ratios in senior athletes (study 1).

Sex	Sport (discipline)	Left-handed				Right-handed				Chi² test of independence			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	χ^2	*p*	*w* and 90% CI	OR and 95% CI
Female	Fencing (épée)	30	24	26	26	136	146	140	101	2.44	0.486	0.06 (0, 0.11)	1.17 (0.65, 2.09)
	Fencing (foil)	39	38	33	33	141	127	110	107	0.19	0.979	0.02 (0, 0)	1.12 (0.66, 1.89)
	Fencing (saber)	32	12	15	12	150	128	130	129	9.08	0.028	0.12 (0.03, 0.18)	0.44 (0.22, 0.88)
	Table tennis	22	26	28	10	122	84	96	78	7.27	0.064	0.12 (0, 0.19)	0.71 (0.32, 1.58)
	Tennis	13	16	9	6	130	116	106	101	3.30	0.347	0.08 (0, 0.14)	0.59 (0.22, 1.62)
	Squash	9	10	9	8	133	111	124	121	0.52	0.914	0.03 (0, 0.05)	0.98 (0.37, 2.61)
Male	Fencing (épée)	38	28	35	35	144	123	128	120	0.80	0.848	0.04 (0, 0.06)	1.11 (0.66, 1.86)
	Fencing (foil)	42	44	34	44	117	134	113	109	1.39	0.708	0.05 (0, 0.09)	1.12 (0.68, 1.85)
	Fencing (saber)	22	22	28	12	156	142	164	125	2.64	0.451	0.06 (0, 0.11)	0.68 (0.32, 1.43)
	Table tennis	23	33	23	28	97	65	88	68	8.04	0.045	0.14 (0.01, 0.2)	1.74 (0.92, 3.27)
	Tennis	14	15	17	12	114	118	96	72	1.35	0.716	0.05 (0, 0.1)	1.36 (0.59, 3.10)
	Squash	11	9	15	11	130	114	108	114	2.22	0.529	0.07 (0, 0.12)	1.14 (0.48, 2.73)

Q1 … Q4, birth quartile 1 (January–March) … birth quartile 4 (October–December); w, standardized Cohen's (1988) effect size; OR, odds ratio based on frequencies observed for right-handers in Q1 vs. Q4 relative to frequencies observed in left-handers in Q1 vs. Q4 (see main text for details). df = 3 for all chi-square comparisons.

month does not seem to stand out as a prominent factor in explaining distributional differences among top-ranked senior athletes in the sports considered. This is in line with previous research on Olympic athletes (Baker et al., 2009).

Supplemental analyses revealed considerable variation in the year-wise relationship between birth month and birth frequency within and between sports in both male and female senior athletes (see **Supplemental Material** for details), indicating that the RAE phenomenon—be it present or not for a particular point in time—should not be assumed of constant magnitude across a broader time window (Schorer et al., 2020). This issue, however, might be of particular relevance at the senior level, where RAE have previously been demonstrated inconsistent (Schorer et al., 2020) and of smaller magnitude as opposed to the junior level (Cobley et al., 2009).

Birthdate Distribution and Handedness

An overview of summary statistics relevant to the chi-square tests of independence between handedness and birth quartile is given in **Table 4**, and the corresponding relative frequencies are displayed in **Figure 2**. Across comparisons, effect size point estimates were mostly below Cohen's (1988) conventional threshold for small effects ($w = 0.10$), and the *upper* limits of the corresponding 90% CIs did not exceed the value of $w = 0.20$ in any comparison. Similarly, across comparisons, odds ratios oscillated around the value of 1 and there was no reliable indication of higher chances in right-handers being born in Q1 than Q4 compared with left-handers being born in Q1 than Q4 (**Table 4**). Overall, analyses do neither provide statistical support for the hypothesis that handedness and relative age are associated nor that the classical RAE pattern in birth quartile distribution

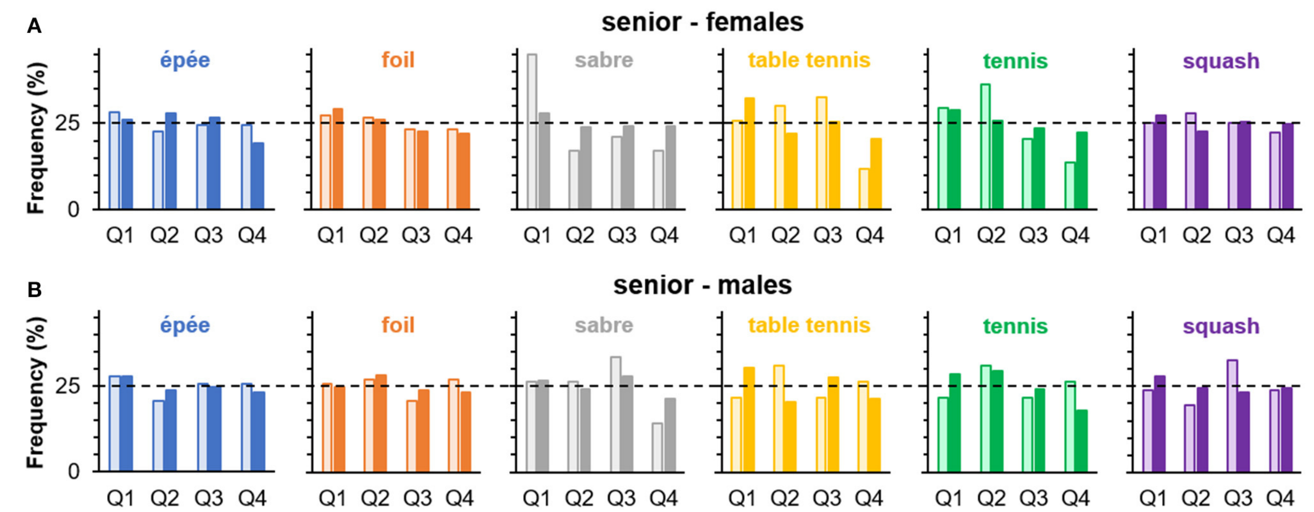

FIGURE 2 | Percentages of birth quartile (Q1–Q4) frequencies in left- (☐) and right-handers (■) separately for sport or discipline in **(A)** female and **(B)** male senior athletes (study 1). Horizontal dashed lines indicate expected frequencies under the assumption of a uniform distribution.

is more pronounced in right- than left-handers. The association found in female saber fencers, for example, is even in contrast to the latter prediction as birth distribution was more skewed toward Q1 in left-handed [45.1%; $w = 0.47$, 90% CI (0.23, 0.64) for a within-handedness goodness-of-fit test against uniform distribution; $OR_{Q1:Q4} = 2.67$, 95% CI (1.37, 5.18)] than right-handed fencers [27.9%; $w = 0.07$, 90% CI (0, 0.12); $OR_{Q1:Q4} = 1.16$, 95% CI (0.92, 1.47)] (see **Figure 2**).

Supplemental analyses were conducted on a year-wise basis with the classification of left- and right-handed athletes as being born either in the first or second half of a year. Contrary to the analyses presented above on data collapsed across the 10-year-period, half-year classification was chosen for supplemental analyses due to otherwise low number of observations for left-handers' birth quartiles. The year-wise chances of right-handers being born in the first vs. the second half of a year relative to left-handers being born in the first vs. the second half of a year were relatively stable within each sport and rarely exceeded the values of 2 (higher chances in right-handers) and 0.5 (higher chances in left-handers; see online **Supplemental Material** for details). Collectively, results from the above analyses do not mirror previous reports on a lower prevalence of left-handed senior athletes born early in the year in comparison with their right-handed counterparts (Schorer et al., 2009; Loffing et al., 2010; Barrenetxea-Garcia et al., 2019).

STUDY 2: RELATIVE AGE EFFECTS AND HANDEDNESS IN WORLD-CLASS JUNIOR ATHLETES

In the former study, the detection of the "classical" RAE phenomenon and its hypothesized association with athletes' handedness might have been hindered by focusing on senior athletes. Remarkably, so far, research on a left-hander advantage in individual interactive sports has exclusively been reported on senior but not junior elite competition. There is compelling evidence that the RAE phenomenon as such reduces from junior to senior level, for example, likely due to the reduction in birth-month-related relative age differences with increasing age (Cobley et al., 2009). Investigating RAE in male- and female-talented Australian cricketers, Connor et al. (2019) suggested that birth distribution was skewed toward quartile 1 in both left- and right-handed batters and bowlers at the younger age groups (e.g., under 15, under 17), but no longer in left- and occasionally in right-handed players at older age groups (i.e., under 19 and state level). Consequently, provided that the RAE phenomenon is more pronounced and that left-handedness is also relevant to performance at the junior level, the hypothesized effect of athletes' handedness in conjunction with birth month might show through more clearly in that particular age group. In study 2, we put this prediction to test by investigating handedness and relative age in internationally top-ranked junior athletes in fencing and tennis.

MATERIALS AND METHODS

Data Retrieval and Data Analyses

The steps related to data retrieval and data analyses were identical to study 1. Here, we focused on the sports of fencing and tennis. For fencing, as in study 1, data on the top 200 athletes were available for each year in each discipline. For tennis, the total number of players listed in year-end rankings ranged from 77 (2009 and 2011) to 98 (2014) in female players and the number of male players ranged from 86 (2009) to 101 (2012) per year-end ranking (see the dataset provided as **Supplementary Material** for details). Overall, a total of $N = 7{,}254$ unique junior athletes were included in the dataset (see **Table 1** for an overview). Compared with senior athletes examined in study 1, the proportion of junior athletes listed twice or more among the top performers in year-end world rankings was clearly lower (36.7% in female tennis to 57.3% in female saber), with the maximum number of years ranging from 4 (male and female tennis) to 7 (all fencing disciplines in females and male foil; see **Supplementary Table 1** for a complete overview). Of note, the athletes considered here as "juniors" are within the age group labeled as "adolescents" (15–18 years) in the meta-analytical review of Cobley et al. (2009).

RESULTS AND DISCUSSION

Handedness Distribution

The number of left-handed junior athletes observed in the 10-year period was higher than expected from the normal population estimate especially in foil (females: 17.43%, males: 20.67%) and épée (junior females: 15.45%, junior males: 18.57%; **Table 5**). In these disciplines, effect size point estimates and the *lower* limits of the associated 90% CIs are located in Cohen's (1988) conventional area of medium effects, suggesting a marked left-hander advantage. For tennis (females: 9.27%, males: 15.3%) and saber (females: 9.43%, males: 11.3%), the results indicate no systematic or marked—in terms of effect sizes and related confidence intervals—left-hander overrepresentation in these sports. Only in male tennis players, there is a small significant effect with an overrepresentation of left-handers.

As illustrated in **Figure 3**, across the 10-year period, left-hander frequencies were quite variable ranging, for example, from 6% (2008 and 2009) to 14.5% (2014) in female saber or from 9.3% (2009) to 21% (2012) in male tennis. This finding contrasts with the stable temporal patterns found in senior athletes (study 1) and highlights that snapshots of left-hander frequencies for a particular year may give an unreliable estimate of the potential role of handedness in junior competition. We speculate that the stronger temporal variation in left-hander frequencies could be due to larger fluctuation of athletes entering and leaving top-ranking positions in juniors compared with seniors. The latter is reflected in larger total numbers of junior than senior athletes included in our fencing and tennis samples (see **Table 1**) as well as in the lower proportions of junior compared with senior athletes listed twice or more in year-end world rankings (see **Supplementary Table 1**). Top juniors move up to the seniors quickly, once they are ready, while seniors may remain for several years up to more than a decade in the same competitive system.

TABLE 5 | Absolute frequencies and results from chi-square goodness-of-fit tests related to handedness in junior athletes (study 2).

Sex	Sport (discipline)	Handedness					
		L	R	N/A	χ^2	*p*	*w* and 90% CI
Female	Fencing (épée)	152	832	0	83.10	<0.001	0.29 (0.24, 0.34)
	Fencing (foil)	163	772	0	124.63	<0.001	0.37 (0.31, 0.42)
	Fencing (saber)	87	836	0	3.87	0.049	0.06 (0, 0.12)
	Tennis	53	519	0	1.97	0.160	0.06 (0, 0.13)
Male	Fencing (épée)	210	921	0	83.68	<0.001	0.27 (0.22, 0.32)
	Fencing (foil)	211	810	3	118.75	<0.001	0.34 (0.29, 0.39)
	Fencing (saber)	117	918	0	1.13	0.288	0.03 (0, 0.08)
	Tennis	99	548	3	17.52	<0.001	0.16 (0.1, 0.23)

L, left-handed; R, right-handed; N/A, handedness not available; w, standardized Cohen's (1988) effect size. df = 1 for all comparisons (see main text for details).

Birthdate Distribution

The "classical" RAE distributional pattern of birth frequencies being skewed toward quartiles 1 (January–March) and 2 (April–June) was evident in both female and male junior athletes (except for female saber; see **Table 6**). The corresponding effect size point estimates, however, were located in the lower half of Cohen's (1988) conventional region of small effects ($w = 0.1$ to 0.3), and the *upper* limits of the associated 90% CIs often did not exceed the value of $w = 0.2$. A notable exception is male tennis, where a medium-sized effect associated with a gradual decrease of birth frequencies from Q1 to Q4 was found (cf. Edgar and O'Donoghue, 2005). Similarly, odds ratios obtained from

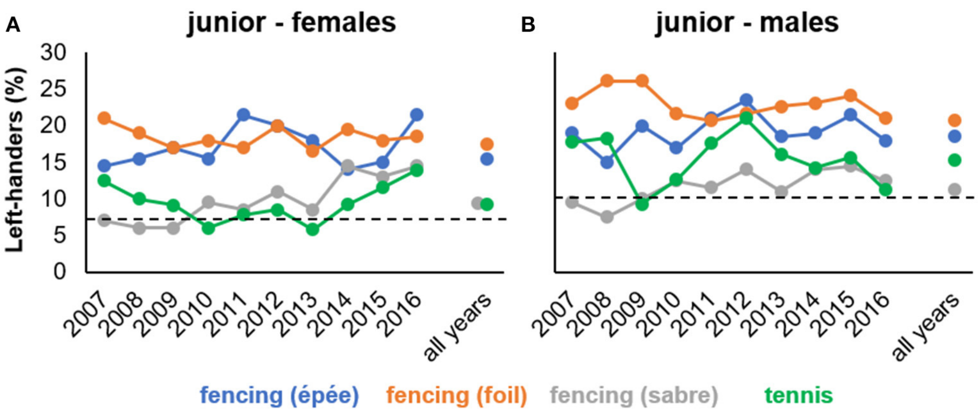

FIGURE 3 | Percentages of left-handed athletes for each year-end ranking and collapsed across all years listed for a particular sport separately for **(A)** female and **(B)** male junior competition (study 2). Horizontal dashed lines represent reference values for normal population estimates of left-handedness in females (7.7%) and males (10.3%), respectively (Raymond et al., 1996).

TABLE 6 | Absolute frequencies, results from chi-square goodness-of-fit tests, and odds ratios related to relative age in junior athletes (study 2).

Sex	Sport (discipline)	Relative age								
		Q1	Q2	Q3	Q4	N/A	χ^2	*p*	*w* and 90% CI	OR and 95% CI
Female	Fencing (épée)	276	289	233	186	0	26.50	<0.001	0.16 (0.1, 0.21)	1.48 (1.23, 1.79)
	Fencing (foil)	270	251	223	191	0	15.21	0.002	0.13 (0.06, 0.17)	1.41 (1.17, 1.70)
	Fencing (saber)	255	220	236	212	0	4.69	0.196	0.07 (0, 0.11)	1.20 (1.00, 1.44)
	Tennis	175	146	151	100	0	20.60	<0.001	0.19 (0.11, 0.25)	1.75 (1.37, 2.24)
Male	Fencing (épée)	321	296	282	232	0	14.91	0.002	0.11 (0.05, 0.16)	1.38 (1.17, 1.64)
	Fencing (foil)	281	295	231	217	0	16.77	0.001	0.13 (0.07, 0.17)	1.29 (1.08, 1.55)
	Fencing (saber)	287	273	261	214	0	11.63	0.009	0.11 (0.04, 0.15)	1.34 (1.12, 1.60)
	Tennis	227	182	137	104	0	53.00	<0.001	0.29 (0.21, 0.35)	2.18 (1.73, 2.75)

Q1 … Q4, birth quartile 1 (January–March) … birth quartile 4 (October–December); N/A, birthdate not available; w, standardized Cohen's (1988) effect size; OR, odds ratio based on frequencies observed for Q1 and Q4 (see main text for details). df = 3 for all chi-square comparisons.

TABLE 7 | Absolute frequencies, results from chi-square tests of independence between handedness and relative age, and odds ratios in junior athletes (study 2).

Sex	Sport (discipline)	Left-handed				Right-handed				Chi²-test of independence			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	χ^2	*p*	*w* and 90% CI	OR and 95% CI
Female	Fencing (épée)	50	40	33	29	226	249	200	157	2.37	0.499	0.05 (0, 0.09)	0.83 (0.51, 1.38)
	Fencing (foil)	39	41	41	42	231	210	182	149	4.78	0.189	0.07 (0, 0.11)	1.67 (1.03, 2.70)
	Fencing (saber)	31	21	21	14	224	199	215	198	4.29	0.232	0.07 (0, 0.11)	0.51 (0.26, 0.99)
	Tennis	20	12	14	7	155	134	137	93	1.77	0.620	0.06 (0, 0.1)	0.58 (0.24, 1.43)
Male	Fencing (épée)	59	45	55	51	262	251	227	181	4.18	0.243	0.06 (0, 0.1)	1.25 (0.82, 1.90)
	Fencing (foil)	49	63	52	47	231	231	178	170	2.48	0.480	0.05 (0, 0.09)	1.30 (0.83, 2.04)
	Fencing (saber)	40	24	34	19	247	249	227	195	5.73	0.125	0.07 (0, 0.11)	0.60 (0.34, 1.07)
	Tennis	34	35	19	11	191	147	118	92	4.09	0.252	0.08 (0, 0.13)	0.67 (0.33, 1.39)

Q1 … Q4, birth quartile 1 (January–March) … birth quartile 4 (October–December); w, standardized Cohen's (1988) effect size; OR, odds ratio based on frequencies observed for right-handers in Q1 vs. Q4 relative to frequencies observed in left-handers in Q1 vs. Q4 (see main text for details). df = 3 for all chi-square comparisons.

the comparison of frequencies observed for Q1 vs. Q4 provide indication for a RAE, particularly in male (OR = 2.18) and female tennis (OR = 1.75; see **Table 6**).

Supplemental analyses revealed variation in the year-wise relationship between birth month and birth frequency within and between sports in both male and female athletes (see **Supplemental Material**), again supporting the notion that the RAE is not necessarily a temporally stable phenomenon even within the same sport or discipline. Compared with the finding for senior athletes in study 1, however, the linear relationships revealed for junior athletes appear more stable and consistent with the "classical" RAE phenomenon known from the literature (Cobley et al., 2009).

Birthdate Distribution and Handedness

Table 7 gives an overview of the summary statistics relevant to the chi-square tests of independence between handedness and birth quartile, and the corresponding relative frequencies are illustrated in **Figure 4**. For all comparisons, effect size point estimates were below Cohen's (1988) conventional threshold for small effects ($w = 0.10$), and the *upper* limits of the corresponding 90% CIs rarely exceed that particular threshold. With regard to odds ratios, there was no systematic and reliable indication of higher chances in right-handers being born in Q1 than Q4 compared with left-handers being born in Q1 than Q4 (**Table 7**). If at all, there was a trend for such pattern in female foil; however, the opposite was found in female saber. Overall, the analyses do neither provide convincing statistical support for the hypothesis that handedness and relative age are interrelated in fencing or tennis nor that the classical RAE pattern in birth quartile distribution is more pronounced in right- than left-handed athletes.

Supplemental analyses revealed that the year-wise chances of right-handers being born in the first vs. the second half of a year relative to left-handers being born in the first vs. the second half of a year were relatively stable within each sport and rarely exceeded the values of 2 (higher chances in right-handers) and 0.5 (higher chances in left-handers; see online **Supplemental Material** for details). Collectively, similar to study 1 for senior athletes, the present findings for junior athletes do not match with previous reports on the predominance of the "classical" RAE phenomenon in right- as opposed to left-handed athletes (Schorer et al., 2009; Loffing et al., 2010; Barrenetxea-Garcia et al., 2019; Connor et al., 2019).

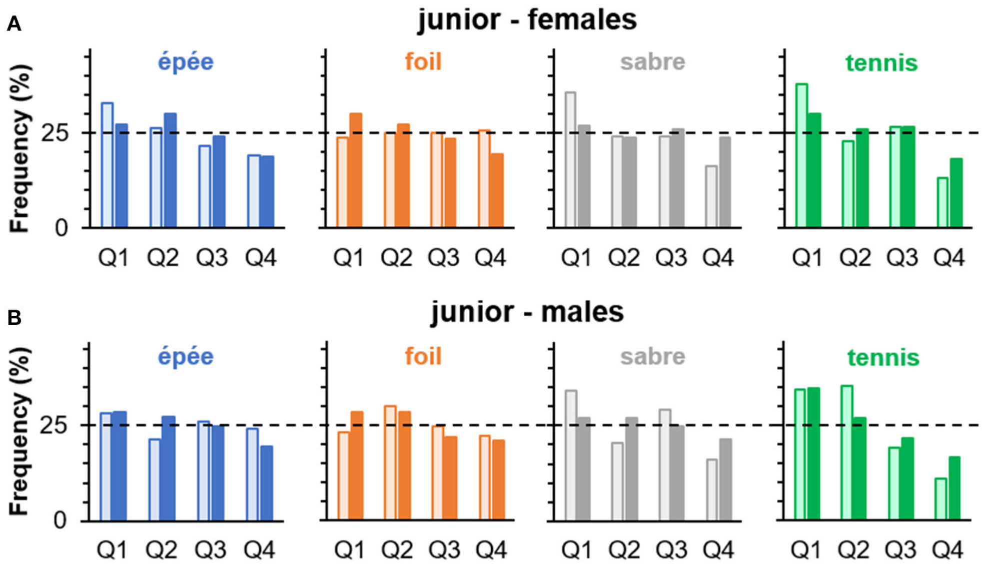

FIGURE 4 | Percentages of birth quartile (Q1–Q4) frequencies in left- (□) and right-handers (■) separately for sport or discipline in **(A)** female and **(B)** male junior athletes (study 2). Horizontal dashed lines indicate expected frequencies under the assumption of a uniform distribution.

GENERAL DISCUSSION

Here, in two studies, we tested whether top-ranked male and female athletes' left-handedness is associated with a lower likelihood of suffering the commonly observed RAE phenomenon as compared with right-handedness in international elite interactive individual sports. Study 1 included senior athletes in fencing (épée, foil, and saber), table tennis, tennis, and squash, while study 2 focused on junior athletes in fencing (all disciplines) and tennis.

In line with previous research on handedness in interactive sports, left-handers were clearly overrepresented in some but not all sports considered (Loffing and Hagemann, 2016; Fagan et al., 2019). At the senior level, an overrepresentation was particularly evident in foil, épée, and table tennis in both female and male competitions (Raymond et al., 1996; Loffing, 2017), whereas at the junior level, this was most evident in foil and épée (females and males) but also in male tennis. The finding of a left-hander overrepresentation at the junior level, which has vastly been neglected in previous research on a handedness-related performance advantage so far (Schorer et al., 2016), provides new insight into the role handedness may play for performance and career development in these different sports. Albeit direct comparisons between the senior and junior findings may be limited, one tentative interpretation of the tennis data is that handedness might still be performance relevant at the junior level in male competition, but no longer stands out at the senior level. The mechanisms behind obviously cannot be clearly identified from the present study design. However, we speculate that this could be due, for example, to better opportunities for targeted match preparation against left-handed senior opponents and more flexible expertise-related adaptation to unfamiliar playing conditions (i.e., playing against a rare left- rather than a common right-hander) (Loffing et al., 2012) in conjunction with relatively lower spatiotemporal pressure compared with other high-pressure interactive sports where a left-hander advantage persists at the senior level (e.g., table tennis; Loffing, 2017). In the fast-interactive fencing disciplines of foil and épée, the left-hander advantage clearly identifiable at the junior level in both males and females persists at the senior level, even to a stronger degree in terms of standardized effect sizes (cf. **Tables 2**, **4**). The lack of consistently enhanced left-hander frequencies in saber competition is surprising in this respect, but on the other hand, this fits with previous research on handedness in fencing (Azémar et al., 1983; Raymond et al., 1996). One explanation for this counterintuitive finding is that the fencing disciplines may impose different demands on sensorimotor processing, favoring either the right hemisphere and thus left-hand control (épée and foil) or the left hemisphere and thus right-hand control (saber) (Boulinguez, 1999; Boulinguez et al., 2001). Since based on the present data we can neither confirm that proposition nor exclude alternative explanations such as greater fighting distance in saber than épée and foil (Raymond et al., 1996), we refrain from speculating further about the potential underlying mechanisms and instead assign this as homework for more in-depth laterality research in fencing. Collectively, in light of the above considerations, it appears to have both theoretical importance and practical relevance to determine the potentially facilitating role laterality, and left-handedness in particular, may play during athletes' developmental pathway from junior to elite international senior competition in interactive sports (Schorer et al., 2016; Connor et al., 2019, 2020).

In general, RAE were within the previously reported range from small to null effect sizes for world-class athletes (Baker et al., 2009). *Post hoc* power estimation using G*Power (version 3.1.9.6; Faul et al., 2007) revealed that the minimum subgroup sample size observed in male senior table tennis ($N = 435$; see **Table 1**) allowed the detection of an effect of Cohen's (1988) $w = 0.2$ or more extreme using goodness-of-fit tests, provided that it truly exists, given $\alpha = 0.05$ and $df = 3$ with a power of 95.3%. Thus, sample sizes were reasonably large enough to detect a small to medium RAE using Cohen's (1988) tentative effect size terminology with sufficiently large power. The *post hoc* power for detecting an even smaller effect of at least $w = 0.1$ with all else being equal, however, ranged from 38.8% (male senior table tennis) to 81.6% (male junior épée, $N = 1{,}131$). Consequently, conclusive interpretation of such small or even smaller effects is limited. This needs to be kept in mind in the following paragraph where we contemplate our RAE findings as well as in general by those who consider the effects of such magnitude as practically relevant.

In our samples, the RAE identified were only larger for junior athletes in tennis in comparison with senior athletes, while in all fencing disciplines, they were highly similar. The results for tennis are in line with the previous observations that RAE decrease from the age group of 15–18-year olds to seniors (Cobley et al., 2009). The contrast to the missing clear age differences in all fencing disciplines might be best explained by the competition hypothesis (Schorer et al., 2009; Lemez et al., 2014; Wattie et al., 2015). There is presumably lower competition in fencing around the world, as there are much less athletes in this sport than for example in tennis, which would be predicted to result in larger effects in tennis than in fencing. Comparing the RAE between sexes shows that for most sports the effect sizes do only marginally differ. In junior tennis, the effect is close to a medium level in male players, according to the effect size conventions by Cohen (1988), whereas the effect (point estimate and confidence interval) is within the range of a small effect in female players. The latter is in line with previous research revealing larger effects for male than female athletes (Cobley et al., 2009; Smith et al., 2018). Surprisingly, there seems to be an opposite trend in senior table tennis. Previous research on table tennis demonstrated larger effects for males than for females in youth players (Faber et al., 2020a,b). Future investigations would need to check if the varying effects found across studies might be due to country-specific influences (e.g., differences in talent identification and selection programs) or if other constraints can be identified that interact here. Taken together, the present results suggest that individual constraints like sex differ only marginally in their association with RAE in the individual interactive sports considered here at both the junior and senior levels.

Considering the hypothesized association between RAE and handedness, the present research does not provide empirical support for the assumption that left-handedness is associated with lower likelihood of suffering the commonly observed RAE phenomenon as compared with right-handedness. In this respect, the comprehensive analyses provided here are an important addition to the paucity of evidence on such hypothesized association in individual interactive sports (Loffing et al., 2010). We speculate that the failure to detect such association, provided that it truly exists at all, might be due to our focus on international elite samples, for which only small to null RAE were identified. Furthermore, given that handedness obviously is a performance-relevant trait in some of the sports investigated here (i.e., épée, foil, and table tennis in particular), the competition for limited resources to develop further and move up the sporting career ladder may be similarly severe for both left- and right-handers in these sports, thus resulting in similar selective pressure acting upon them and making both handedness groups almost equally prone to possible birth-related inequalities (Baker et al., 2009; Cobley et al., 2009; Schorer et al., 2020). Since in the present study our focus was on international competition, future work may need to check whether the pattern of null findings reported here also holds at the national level. Furthermore, it is vital to keep in mind that handedness might still interact with RAE in other areas like team sports, where positional demands like in handball and water polo (Schorer et al., 2009; Barrenetxea-Garcia et al., 2019) or strategic considerations to enhance team flexibility as suggested in batting sports (Brooks et al., 2004; Hirotsu and Wright, 2005) may favor the selection of left-handed players irrespective of their relative age (Connor et al., 2019). A similar principle might also apply to the selection of rare left-footed players, for example, in soccer (Verbeek et al., 2017). Future research might want to focus on younger age groups during their development with expected larger RAE. The athletes of the current study have been through all developmental systems and made it to the top. World-class athletes, however, might not be substantially affected by the developmental factor relative age anymore (Baker et al., 2009; Cobley et al., 2009; Schorer et al., 2020). The present findings add to the developmental systems model (Wattie et al., 2015) by highlighting that handedness may indeed be a performance-relevant trait, which, however, was not found to substantially interact with RAE in the elite interactive individual sports considered here. Future consideration of the abovementioned steps like focusing on a sport's national level as well as extending the view on team sports is suggested to further unravel the potential interaction between laterality and RAE as proposed by the model.

One potential methodological limitation is that we were unable to check for cutoff dates in all countries included in the analyses. Given that the IOC ruled out the first of January as international cutoff date, however, this might be more of a theoretical rather than a serious "results-biasing" problem. Still, the UK is known as an exception in applying September 1st as the cutoff date for national level youth competition (Till et al., 2010; Kelly et al., 2020a,b). To account for this, we rerun all analyses reported for studies 1 and 2 with UK athletes' birthdates being classified relative to September 1st and birthdates of athletes from all other nations relative to January 1st. The corresponding results are reported in detail in Section B of the **Supplementary Material**. In essence, the results obtained from the "mixed cutoff date" classification do not markedly differ from the results obtained from the uniform cutoff date (i.e., January 1st) reported here in the main text. Consequently, as we are not aware of any other (big) nation employing a cutoff date different to January 1st at the national level, we are confident that the findings reported here are reliable and not confounded or biased by insufficiently defined cutoff date criteria. The use of an estimated uniform distribution for the goodness-of-fit tests on birthdate distributions might constitute another limitation as recently outlined by Delorme and Champely (2015). We therefore considered these authors' recommendation and ran additional analyses against a day-corrected distribution of expected birth quartile frequencies. Importantly, the effect size point estimates as well as the limits of the corresponding confidence intervals are almost identical to those obtained from the analyses reported here in **Tables 2**, **4** for a uniform distribution assumption (see Section A of the **Supplementary Material** for details). Thus, the above-discussed conclusions on RAE remain the same irrespective of whether the inferential results from uniform or day-corrected tests are considered. As another final limitation, sample sizes were restricted through our focus on the top performers in the respective sports. Firm conclusions regarding a potential association between RAE and handedness are limited by the small samples of left- compared with right-handed athletes, particularly in the domains of squash and tennis.

Taken together, the two studies reported here sought to close a gap in research on the association of RAE and handedness. Given that our sample comprised world-class athletes, our results apply to the association of handedness and RAE at the final stages of the development toward sporting expertise. Recently, the developmental importance of RAE has been emphasized again (Schorer et al., 2020). Therefore, future research on laterality and RAE is recommended to first look at younger age groups, when athletes are in their main developmental period, and second, research would highly benefit from more longitudinal data. Then, dropouts from, joiners in, and remainders in the system could be identified, which would allow a much closer look at the hypothesized association between handedness and RAE.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements. Written informed consent was not obtained from the individual(s), nor the minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

Both authors developed the study concept and contributed to the study design. Testing and data collection were performed under the supervision of FL. FL performed the data analysis. FL and JS interpreted the data. FL and JS drafted the manuscript. Both authors approved the final version of the manuscript for submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2021.662203/full#supplementary-material

REFERENCES

Addona, V., and Yates, P. A. (2010). A closer look at the relative age effect in the National Hockey League. *J. Quant. Anal. Sports* 6:1227. doi: 10.2202/1559-0410.1227

Azémar, G., Ripoll, H., Simonet, P., and Stein, J. F. (1983). Étude neuro-psychologique du comportement des gauchers en escrime. *Cinésiologie* 22, 7–18.

Baker, J., Schorer, J., Cobley, S., Schimmer, G., and Wattie, N. (2009). Circumstantial development and athletic excellence: the role of date of birth and birthplace. *Eur. J. Sport Sci.* 9, 329–339. doi: 10.1080/17461390902933812

Barrenetxea-Garcia, J., Torres-Unda, J., Esain, I., and Gil, S. M. (2019). Relative age effect and left-handedness in world class water polo male and female players. *Laterality* 24, 259–273. doi: 10.1080/1357650X.2018.1482906

Boulinguez, P. (1999). Les avantages liés à la latéralité manuelle en escrime sont-ils l'expression d'asymétries cérébrales fonctionnelles? *Schweiz. Zeitschri Sportmed. Sporttraumatol.* 47, 63–67.

Boulinguez, P., Velay, J. L., and Nougier, V. (2001). Manual asymmetries in reaching movement control. II: Study of left-handers. *Cortex* 37, 123–138. doi: 10.1016/S0010-9452(08)70562-8

Breznik, K. (2013). On the gender effects of handedness in professional tennis. *J. Sports Sci. Med.* 12, 346–353.

Bronfenbrenner, U. (2000). *Ecological Systems Theory.* New York, NY: Oxford University Press. doi: 10.1037/10518-046

Bronfenbrenner, U., and Ceci, S. J. (1994). Nature-nuture reconceptualized in developmental perspective: a bioecological model. *Psychol. Rev.* 101, 568–586. doi: 10.1037/0033-295X.101.4.568

Brooks, R., Bussière, L. F., Jennions, M. D., and Hunt, J. (2004). Sinister strategies succeed at the cricket World Cup. *Proc. R. Soc. Lond. Ser. B Biol. Sci.* 271, S64–S66. doi: 10.1098/rsbl.2003.0100

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S. P., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Erlbaum.

Connor, J. D., Mann, D. L., Gomez, M.-A., Leicht, A. S., and Doma, K. (2020). Performance advantages of left-handed cricket batting talent. *Front. Psychol.* 11: 1654. doi: 10.3389/fpsyg.2020.01654

Connor, J. D., Renshaw, I., and Doma, K. (2019). Moderating factors influence the relative age effect in Australian cricket. *Peer J.* 7:e6867. doi: 10.7717/peerj.6867

Deaner, R. O., Lowen, A., and Cobley, S. (2013). Born at the wrong time: selection bias in the NHL draft. *PLoS ONE* 8:e57753. doi: 10.1371/journal.pone.0057753

Delorme, N., and Champely, S. (2015). Relative age effect and chi-squared statistics. *Int. Rev. Soc. of Sport* 50, 740–746. doi: 10.1177/1012690213493104

Dixon, J. C., Horton, S., Chittle, L., and Baker, J. (2020). *Relative Age Effects in Sport—International Perspectives.* London: Routledge. doi: 10.4324/9781003030737

Edgar, S., and O'Donoghue, P. (2005). Season of birth distribution of elite tennis players. *J. Sports Sci.* 23, 1013–1020. doi: 10.1080/02640410400021468

Faber, I. R., Liu, M. H., Cece, V., Jie, R., Martinent, G., Schorer, J., et al. (2020a). The interaction between within-year and between-year effects across ages in elite table tennis in international and national contexts—a further exploration of relative age effects in sports. *High Ability Stud.* 31, 115–128. doi: 10.1080/13598139.2019.1596071

Faber, I. R., Martinent, G., Cece, V., and Schorer, J. (2020b). Are performance trajectories associated with relative age in French top 100 youth table tennis players? A longitudinal approach. *PLOS ONE* 15:e0231926. doi: 10.1371/journal.pone.0231926

Fagan, F., Haugh, M., and Cooper, H. (2019). The advantage of lefties in one-on-one sports. *J. Quant. Anal. Sports* 15:1. doi: 10.1515/jqas-2017-0076

Faul, F., Erdfelder, E., Lang, A.-G., and Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* 39, 175–191. doi: 10.3758/BF03193146

Goldstein, S. R., and Young, C. A. (1996). "Evolutionary" stable strategy of handedness in major league baseball. *J. Comp. Psychol.* 110, 164–169. doi: 10.1037/0735-7036.110.2.164

Grouios, G. (2004). Motoric dominance and sporting excellence: training versus heredity. *Percept. Motor Skills* 98, 53–66. doi: 10.2466/pms.98.1.53-66

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Harris, L. J. (2016). "In fencing, are left-handers trouble for right-handers? What fencing masters said in the past and what scientists say today," in *Laterality in Sports: Theories and Applications,* eds F. Loffing, N. Hagemann, B. Strauss and C. MacMahon. (San Diego, CA: Academic Press), 31–64. doi: 10.1016/B978-0-12-801426-4.00003-1

Hirotsu, N., and Wright, M. (2005). Modelling a baseball game to optimise pitcher substitution strategies incorporating handedness of players. *IMA J. Manag. Math.* 16, 179–194. doi: 10.1093/imaman/dpi009

Holtzen, D. W. (2000). Handedness and professional tennis. *Int. J. Neurosci.* 105, 101–119. doi: 10.3109/00207450009003270

Kelly, A. L., Jackson, D. T., Taylor, J. J., Jeffreys, M. A., and Turnnidge, J. (2020a). "Birthday-banding" as a strategy to moderate the relative age effect: a case study into the England squash talent pathway. *Front. Sports Active Living* 2:573890. doi: 10.3389/fspor.2020.573890

Kelly, A. L., Wilson, M. R., Gough, L. A., Knapman, H., Morgan, P., Cole, M., et al. (2020b). A longitudinal investigation into the relative age effect in an English professional football club: exploring the 'underdog hypothesis'. *Sci. Med. Football* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Lemez, S., Baker, J., Horton, S., Wattie, N., and Weir, P. (2014). Examining the relationship between relative age, competition level, and dropout rates in male youth ice-hockey players. *Scand. J. Med. Sci. Sports* 24, 935–942. doi: 10.1111/sms.12127

Loffing, F. (2017). Left-handedness and time pressure in elite interactive ball games. *Biol. Lett.* 13:20170446. doi: 10.1098/rsbl.2017.0446

Loffing, F., and Hagemann, N. (2012). "Side bias in human performance: areview on the left-handers' advantage in sports," in *Bias in Human Behaviour,* eds T. Dutta, M. Mandal and S. Kumar. (Hauppauge, NY: Nova Science), 163–182.

Loffing, F., and Hagemann, N. (2015). Pushing through evolution? Incidence and fight records of left-oriented fighters in professional boxing history. *Laterality* 20, 270–286. doi: 10.1080/1357650X.2014.961471

Loffing, F., and Hagemann, N. (2016). "Performance differences between left- and right-sided athletes in one-on-one interactive sports," in *Laterality in Sports: Theories and Applications,* eds F. Loffing, N. Hagemann, B. Strauss and C. MacMahon (San Diego, CA: Academic Press), 249–277. doi: 10.1016/B978-0-12-801426-4.00012-2

Loffing, F., Hagemann, N., and Strauss, B. (2012). Left-handedness in professional and amateur tennis. *PLoS ONE* 7:e49325. doi: 10.1371/journal.pone.0049325

Loffing, F., Schorer, J., and Cobley, S. P. (2010). Relative age effects are a developmental problem in tennis: but not necessarily when you're left-handed! *High Ability Stud.* 21, 19–25. doi: 10.1080/13598139.2010.488084

Malagoli Lanzoni, I., Semprini, G., Di Michele, R., and Merni, F. (2013). Top athletes handedness in the major racket sports. *Int. J. Table Tennis Sci.* 8, 160–163.

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Newell, K. M. (1986). "Constraints on the development of coordination," in *Motot Development in Children: Aspects of Coordination and Control,* eds M. G. Wade and H. T. A. Whiting (Amsterdam: Martin Nijhoff), 341–361. doi: 10.1007/978-94-009-4460-2_19

O'Donoghue, P. (2009). Relative age in elite tennis. *Stud. Phy. Cult. Tourism* 16, 379–388.

Raymond, M., Pontier, D., Dufour, A. B., and Møller, A. P. (1996). Frequency-dependent maintenance of left handedness in humans. *Proc. R. Soc. Lond. Ser. B Biol. Sci.* 263, 1627–1633. doi: 10.1098/rspb.1996.0238

Romann, M., and Fuchslocher, J. (2014). The need to consider relative age effects in women's talent development process. *Percept. Motor Skills* 118, 651–662. doi: 10.2466/30.10.PMS.118k24w8

Romann, M., Rössler, R., Javet, M., and Faude, O. (2018). Relative age effects in Swiss talent development—a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–2031. doi: 10.1080/02640414.2018.1432964

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., and Baker, J. (2009). Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scan. J. Med. Sci. Sports* 19, 720–730. doi: 10.1111/j.1600-0838.2008.00838.x

Schorer, J., Roden, I., Büsch, D., and Faber, I. (2020). "Relative age effects are developmental! The necessity of looking at more than one time point," in *Relative Age Effects in Sport: International Perspectives,* eds. J. C. Dixon, S. Horton, L. Chittle and J. Baker (New York, NY: Routledge), 33–45. doi: 10.4324/9781003030737-4

Schorer, J., Tirp, J., Steingröver, C., and Baker, J. (2016). "Laterality and its role in talent identification and athlete development," in *Laterality in Sports: Theories and Applications,* eds F. Loffing, N. Hagemann, B. Strauss and C. MacMahon. (San Diego, CA: Academic Press), 87–105. doi: 10.1016/B978-0-12-801426-4.00005-5

Schorer, J., Wattie, N., and Baker, J. R. (2013). A new dimension to relative age effects: constant year effects in German youth handball. *PLoS ONE* 8:e60336. doi: 10.1371/journal.pone.0060336

Sherar, L. B., Baxter-Jones, A. D. G., Faulkner, R. A., and Russell, K. W. (2007). Do physical maturity and birth date predict talent in male youth ice hockey players? *J. Sports Sci.* 25, 879–886. doi: 10.1080/02640410600908001

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Till, K., Cobley, S., Wattie, N., O'Hara, J., Cooke, C., and Chapman, C. (2010). The prevalence, influential factors and mechanisms of relative age effects in UK Rugby League. *Scand. J. Med. Sci. Sports* 20, 320–329. doi: 10.1111/j.1600-0838.2009.00884.x

Verbeek, J., Elferink-Gemser, M. T., Jonker, L., Huijgen, B. C. H., and Visscher, C. (2017). Laterality related to the successive selection of Dutch national youth soccer players. *J. Sports Sci.* 35, 2220–2224. doi: 10.1080/02640414.2016.1262544

Wattie, N., Baker, J., Cobley, S., and Montelpare, W. J. (2007). A historical examination of relative age effects in Canadian hockey players. *Int. J. Sport Psychol.* 38, 178–186.

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

Zhang, B., Lemez, S., Wattie, N., and Baker, J. (2018). A historical examination of relative age effects in Major League Baseball. *Int. J. Sport Psychol.* 49, 448–463.

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ORIGINAL RESEARCH
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Relative Age-Related Biases in Objective and Subjective Assessments of Performance in Talented Youth Soccer Players

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Talent research has recommended that multidimensional assessments of performance are needed to improve the identification and development of talented young athletes. However, factors such as the relative age effect may cloud our ability to assess factors related to performance. The aim of this study was to determine the extent of any relationship between soccer players' chronological and relative age, and objective and subjective performance assessments. Data for highly talented male soccer players selected into the German Soccer Associations' talent promotion program ($N = 16{,}138$) for U12 to U15 age groups ($M_{age} = 12.62 \pm 1.04$ years) were examined. Besides anthropometric assessments, players completed a battery of five motor tests that objectively assessed speed abilities and technical skills (specifically sprint, agility, dribbling, ball control, and juggling). In addition, coaches subjectively rated players on their kicking, tactical, and psychosocial skills, as well as providing holistic evaluations of each player's current and future performance levels. Correlation analyses were used to investigate the extent of any relationships between the chronological and relative age of players and their results for each of the assessments. A strong linear decrease in the frequency of later-born players confirmed the overrepresentation of early-born players in all age groups ($0.92 \leq |r| \leq 0.95$, each $p < 0.001$). From U12 to U15, significant (each $p < 0.001$) correlations were found between the chronological age of players and their height ($|r| = 0.70$), weight ($|r| = 0.69$), speed abilities ($|r| = 0.38$), and technical skills ($|r| = 0.43$). When evaluating each age group separately, small effects were found when correlating relative age with the anthropometric assessments ($0.18 \leq |r| \leq 0.26$), and only trivial effects with speed abilities and technical skills ($0.01 \leq |r| \leq 0.06$). Similarly, low correlations were found for the subjective evaluations of kicking, tactical, and psychosocial skills with chronological age across age groups ($0.03 \leq |r| \leq 0.07$), and with relative age in each age group ($0.01 \leq |r| \leq 0.11$). The results show a skewed distribution toward early-born players and—in reference to their relative age—advanced performance in late-born athletes. However, trends toward a better holistic rating of early-born players for current and future performance levels were found. Coaches should be aware of these effects during talent selection, but also when interpreting results from subjective and objective assessments of performance.

Keywords: football, motor diagnostics, coaches' eye, subjective evaluation, multidimensional approach, talent development

INTRODUCTION

The identification of talented soccer players is a key challenge for both researchers and practitioners. The difficulty in identification can be attributed to the many factors that can influence the development of young players, including their anthropometric, physiological, technical, tactical, or psychological characteristics, as well as environmental and sociological influences (Hoare and Warr, 2000; Unnithan et al., 2012; Suppiah et al., 2015; Larkin and O'Connor, 2017). As a result, a variety of performance factors should be considered to determine which youth soccer players have the highest potential to develop to an elite level (Buekers et al., 2015). Therefore, past research has examined objective and subjective diagnostics that assess performance factors that might discriminate between skilled and less-skilled players. A variety of objective measures of performance have been investigated, including those that assess speed (e.g., Gil et al., 2014), technical skills (e.g., Höner et al., 2017; Bergkamp et al., 2019), perceptual-cognitive skills (e.g., Murr et al., 2020), and psychological attributes (e.g., Toering et al., 2009; Höner and Feichtinger, 2016). Each has been shown to be related to future success in soccer. Subjective assessments, although more controversial, are sometimes beneficial because coaches and scouts can evaluate player characteristics that might be difficult to measure. Therefore, coaches often subjectively not only evaluate the specific characteristics of players but also sometimes provide a holistic evaluation of the current performance of a player or their future potential (Mann, 2020). For instance, coaches may attempt to evaluate the "coachability" of a player and to take that into account when making a holistic judgment of that player's level of talent (Larkin and O'Connor, 2017).

For the optimal monitoring and development of young talented athletes, researchers have called for a multidimensional assessment of prognostically relevant performance factors that combine both objective *and* subjective assessments to integrate the benefits from both approaches (Ford et al., 2020; Williams et al., 2020). Indeed, recent studies reinforce the benefits of a multidimensional approach. For instance, Sieghartsleitner et al. (2019) found that a combination of subjective coach evaluations of in-game performance in addition to objective performance data was significantly more predictive of future playing status than solely objective performance data. Similarly, Höner et al. (in revision) found the best prediction of U12 to U15 players' future success (i.e., selection into a youth academy) when using a combination of objective motor diagnostics (i.e., sprint, agility, dribbling, ball control, and juggling) and subjectively rated performance factors (i.e., kicking skills, endurance, individual tactical skills, and psychosocial skills).

However, factors exist that may impact these multidimensional objective and subjective assessments of talent. One of these factors is the *relative age effect* (RAE). The RAE is characterized by a systematically skewed distribution of selected players according to their date of birth, where earlier-born players are typically overrepresented (Cobley et al., 2008). Wattie et al. (2015) explain the emergence of RAEs in sports based on Newell's (1986) constraints-based model. RAEs occur not due to a single factor but rather due to a complex interaction of individual constraints (e.g., an individual's date of birth, maturation, and abilities), environmental constraints (e.g., talent promotion programs and coaches), and task constraints (e.g., the physical and physiological demands of the sport). This interaction leads to advantages for early-born players in athletically demanding sports such as track and field (Romann and Cobley, 2015), ice hockey (Nolan and Howell, 2010), handball (Wrang et al., 2018), basketball (López de Subijana and Lorenzo, 2018; Kalén et al., 2021), and soccer (Votteler and Höner, 2017; Hill et al., 2020a; Romann et al., 2020; Yagüe et al., 2020). This is particularly the case in team sports, where the specific demands of different playing positions can even be associated with different RAEs (Wattie et al., 2015). However, RAEs are not found in all sports and can be reversed in some sports such as gymnastics (Baker et al., 2014). An environmental factor that contributes to the emergence of RAEs is the volume of high-performing athletes competing in the sport, with greater competition leading to stronger RAEs (Baker et al., 2014).

RAEs are particularly present in soccer. Studies consistently show an overrepresentation of earlier-born players in representative soccer teams but that the magnitude of the effect is influenced by factors such as the age group and performance level of the players (Castillo et al., 2019; Hill et al., 2020a,b; Kelly and Williams, 2020). For instance, it had been shown that the extent of the RAE increases in higher performance levels in youth soccer (Johnson et al., 2017; Votteler and Höner, 2017; Schroepf and Lames, 2018; Jackson and Comber, 2020). Jackson and Comber (2020) recently found a striking overrepresentation of U9 English youth academy players born in the first birth quarter compared with players born in the fourth birth quarter (odds ratio of 8.6), even though those players were selected from regional leagues where only a small RAE was present. Votteler and Höner (2017) found that, depending on age group, 66–69% of the youth academy players in Germany, and even 72–81% of the German youth national players, are born in the first half of the year. While the RAE is still present in adult professional soccer leagues, its extent is considerably smaller than in youth soccer (e.g., Doyle and Bottomley, 2018; Yagüe et al., 2020).

Within the process of identifying and developing talented soccer players, objective and subjective assessments of performance can reflect different constraints in the theoretical framework of RAEs in sport (Wattie et al., 2015). Objective assessments (e.g., motor tests) align with task constraints by assessing predictors that correspond to soccer-specific requirements (e.g., technical skills). If player performance is rated subjectively by coaches, the coaches belong to the environmental constraints, because they support the players in their development. Thus, it is of vital importance to be aware of the magnitude of age-related biases in both objective and subjective assessments that were used to identify and develop talented soccer players.

A number of studies have examined age-related biases in the objective assessment of performance in soccer-specific predictors of talent (Votteler and Höner, 2014). The magnitude of these biases depends on the specific talent predictors as well as the quality of the players tested. For instance, a large relationship has been found between the relative age of players and their physical and physiological performance (Duarte et al., 2019). However, some studies have shown physical and physiological test performance to be more closely associated with the players' biological maturity than their relative age (Deprez et al., 2012, 2013; Parr et al., 2020). In these studies, late-born players in the selection were found to be earlier maturing such that no differences were found in the biological maturity between players in the different birth quarters.

Few studies have investigated the impact of RAEs on subjective assessments of talent in soccer. Recently, Hill et al. (2020b) investigated whether the relative and biological age of U9 to U16 English youth academy players was associated with the game performance ratings of the players provided by their coaches. While the maturation status of the youth players was positively associated with higher match performance ratings in the U10, U14, and U15 age groups, relative age was not significantly associated with coach ratings of performance in any of the age groups. Furley and Memmert (2016) investigated whether coaches' evaluations of youth soccer players' domain-specific giftedness were biased by players' body size. The Implicit Association Test was used where the coaches rated players, that were presented in video format as point-light displays, by rating 12 soccer-specific attributes. Medium-to-strong associations between players' body size and coach ratings were found. In other words, coaches implicitly associated positive performance attributes with being tall and negative performance attributes with being short. In another study by Peña-González et al. (2018), the association was investigated between differences in the age, anthropometry, and physical performance of Spanish soccer players and how coaches expected players to perform. The early-born players (in the investigated U12 to U16 age groups) were not taller or heavier, nor did they show better physical performance. Nevertheless, coaches had greater expectations that the early-born players would demonstrate superior physical performance and a greater general ability to play soccer. In line with this, Figueiredo et al. (2019) investigated whether coaches' evaluations of the potential success of 11- and 13-year-old Portuguese soccer players differed between players born in different birth quarters. Coaches tended to rate the potential of players born in the first birth quarter higher than that of those born later. The ratings systematically declined by birth quarter, although no differences were found in the maturity status, functional capacities, or soccer-specific skills of the older players.

Although the existing studies investigating age-related biases in coaches' subjective ratings of performance have unveiled important insights into judgments of talent, those studies have important shortcomings that potentially limit the generalizability of the findings. In particular, these studies rely on small sample sizes and/or utilize instruments for subjective ratings whose psychometric properties or prognostic validity remain unknown. Moreover, there are substantial differences among the studies with respect to the predictors that were used to rate youth soccer players' performance characteristics. For instance, some studies (Figueiredo et al., 2019; Hill et al., 2020b) utilized only single items to rate the overall performance of players. This approach may have benefits from a practical point of view, but it does not allow for a comprehensive insight into the particular aspects of player performance that are impacted by subjective biases (Diamantopoulos et al., 2012). Accordingly, research is needed that investigates age-related biases in a range of objective *and* subjective assessments of talent across a range of domain-specific characteristics likely to be predictive of performance.

The Present Study

The aim of the present study was to investigate the association between the relative ages of talented youth soccer players and their outcomes on objective and subjective assessments of their performance. Players within the U12 to U15 age groups of the talent promotion program of the German Football Association (DFB) took part in the study. Players were selected into one of the 366 national competence centers (CCs) where they were provided with one additional training session per week conducted by qualified coaches. In order to monitor the players' development within the program and to provide coaches and other stakeholders with valuable information about player performance, players participated in both objective and subjective assessments as part of the promotion program. Given the multidimensional nature of talent (Buekers et al., 2015), these objective and subjective assessments focus on a variety of predictors of talent in soccer. Besides anthropometric measurements (height and weight), the speed abilities and soccer-specific technical skills of players were assessed using an objective diagnostic battery of five motor tests (Höner et al., 2015). Furthermore, the technical, tactical, physiological, and psychosocial skills of the players are rated annually by their coaches using subjective rating scales whose psychometric properties and prognostic relevance have been validated (Höner et al., in revision). These subjective assessments include a holistic rating of each player's current and expected future level of performance.

Regarding the players' outcomes for the objective diagnostics, as a consequence of training and/or maturation, progressive increases in player performance with increasing chronological age were expected for both their anthropometrics and their motor performance (i.e., across all age groups). Given an unselected and, therefore, unbiased population of players, such a relationship would also be expected to be found between players' relative age and these test performances *within* each age group (i.e., U12, U13, U14, and U15). However, previous research suggested that the performance of later-born children within age cohorts must be at least as good as that of the earlier-born children to achieve selection in the same group (e.g., Roberts et al., 2020). As a result, associations between relative age and performance might not exist within age groups for parameters that are judged to be important for performance in soccer. When making subjective evaluations of talent, coaches were asked to rate the players relative to other players of the same age. Therefore, no association was expected between chronological age and subjective performance when investigating all participants together (i.e., combining all age groups). However, subjective ratings *within* specific age groups were expected to improve with increasing relative age given a players' development during the year. In other words, for all subjectively evaluated performance characteristics, players born in January should be rated, on average, better than players born in December.

METHOD

Sample and Design

The sample consisted of $N = 16{,}138$ male players in the age groups U12, U13, U14, or U15 who were promoted at one of the CCs (born between 2001 and 2006; $M_{age} \pm SD = 12.62 \pm 1.04$ years). Testing was conducted in each of the 2015/2016 (birth cohorts 2001–2004), 2016/17 (2002–2005), and 2017/2018 seasons (2003–2006). At the time of data collection, the players were part of the DFB's talent promotion program and participated in the nationwide objective and subjective diagnostics (Höner et al., in revision, 2015).

Before entering the talent promotion program, a legal guardian provided written informed consent for the recording and scientific use of each player's data. DFB staff members both conducted the motor diagnostic testing and performed the subjective evaluations of the players. The DFB provided the authors with data for the six birth cohorts (2001–2006). The university's ethics department approved the use of the data for the purposes of this study.

Measures

Objective Motor Diagnostics

This battery of tests consists of five individual tests designed to assess players' speed abilities and technical skills (for details, see Höner et al., 2015). Specifically, sprint ability was measured by the time to complete a 20-m linear sprint. The agility[1] test measured the time taken to complete a slalom course without a ball (three long and four short distances running between six slalom poles, 21.9-m total distance when assuming linear running). The test of dribbling measured the time taken to complete the agility slalom course with a ball. The test of ball control recorded the time needed to play six passes alternately against two opposing walls (pass length 3 m). For juggling, players were assessed on their ability to juggle the ball alternately with their left and right feet through as many subsections of a figure-eight course without ground contact. The course consisted of eight subsections to be repeated as many times as possible within 45 s (distance between the markings of each subsection: 2.1 m). A player scores one point per completed subsection, with the total points scored within the allotted time recorded. The times for the sprint, agility, and dribbling tests were measured using light gates (Brower TC Timing, Draper, USA). Times for the ball control test were established using hand-stopped chronographs. Each test was performed twice, with the best result recorded. Players were given sufficient time between the tests to recover (approximately 3 min after each attempt). The time-based tests (sprint, agility, dribbling, and ball control) were coded negatively so that lower values represented better performance. For the juggling test, a higher value represented better performance. The psychometric properties of the motor test battery were analyzed by Höner et al. (2015) for a sample of almost 70,000 male CC players. They found excellent internal consistencies (Cronbach's alpha) for sprint ($0.92 \leq \alpha \leq 0.93$ for U12, U13, U14, and U15) and agility ($0.90 \leq \alpha \leq 0.90$). The value for juggling was satisfying ($0.72 \leq \alpha \leq 0.75$), while the values for dribbling ($0.53 \leq \alpha \leq 0.57$) and ball control ($0.61 \leq \alpha \leq 0.64$) were slightly lower.

Subjective Performance Evaluation

The subjective evaluations of the players were carried out by 1,300 CC coaches, each of whom held at least a UEFA B coaching license. To ensure that the evaluations were as uniform as possible, the CC coaches were given a 16-page manual in which each of the aspects of subjective performance was explained (see Höner et al., in revision). Overall, coaches were required to subjectively evaluate the performance of the CC players on each of 15 items (see **Table 1**): 13 measures of individual aspects of performance and two holistic measures of player performance[2]. The 13 *individual aspects of performance* were rated with reference to that player's respective age group (i.e., U12 to U15).

Of the 13 individual aspects of performance, three items related to capabilities within the player's motor domain (kicking the ball with the dominant and non-dominant legs, heading), seven to the perceptual-cognitive domain (behavior in offensive and defensive situations before, during, and after ball-related actions, and game intelligence), and three to the personality-related domain (motivational, volitional, and social skills). The motor and perceptual-cognitive domains were each evaluated by

[1]There are inconsistent definitions of agility in the literature (Sheppard et al., 2014). In the present study, agility was considered to be a speed-related motor ability that does not include cognitive aspects such as reactive decision-making. Saward et al., 2020 emphasized this physiological aspect of change of direction by using the term "slalom agility speed".

[2]The subjective performance evaluation also comprises ratings of players' performance regarding endurance. This domain-specific rating was conducted utilizing a single item and was, therefore, excluded from the considerations of the present study.

TABLE 1 | Subjectively assessed youth players' performance factors (modified from Höner et al., in revision).

Domain	Performance factor (# items)	Items for subjective evaluation of youth players' performance factors
Motor	Kicking skills (3)	- Kicking the ball with ∘ Dominant leg ∘ Non-dominant leg - Heading
Perceptual-cognitive	Individual tactical skills (7)	- Behavior in offensive situations ∘ Before ball-related actions ∘ During ball-related actions ∘ After ball-related actions - Behavior in defensive situations ∘ Before ball-related actions ∘ During ball-related actions ∘ After ball-related actions - Game intelligence
Personality-related	Psychosocial skills (3)	- Motivational skills - Volitional skills - Social skills
Holistic	Overall current skills (1)	- Current performance level
	Overall future skills (1)	- Future performance level

coaches with reference to players' age group using a four-point rating scale: "below-average CC level" (0); "average CC level" (1); "level of the extended squad for regional association team" (2); or "level of core team for the regional association team" (3). Regarding psychosocial skills, no direct reference to the CC or the regional association team was made due to the difficulty of such an assessment. Instead, the coaches were asked to evaluate their players with reference to that players' age group using the scale "below average level" (0); "average level (1); "high level" (2); or "very high level" (3).

The scores for the aspects of performance in the motor, perceptual-cognitive, and personality-related domains were averaged to provide a measure of *kicking skills* (motor domain), *individual tactical skills* (perceptual-cognitive domain), and *psychosocial skills* (personality-related domain) and were used for further data analyses. The reliability values in terms of internal consistency (Cronbach's alpha) for the subjective performance scales tactical skills ($0.89 \leq \alpha \leq 0.91$ for U12, U13, U14, and U15) and psychosocial skills ($0.84 \leq \alpha \leq 0.87$) were excellent. Kicking skills ($0.73 \leq \alpha \leq 0.77$) showed at least satisfying values.

In addition, the two *holistic subjective assessments* were used to evaluate the current and anticipated future performance levels of the players. Here, coaches were asked to rate the overall impression of each player from a holistic perspective. Coaches could therefore consider their own additional criteria, i.e., not only those that were covered by the 13 measures of individual performance. To evaluate the current performance level, coaches were asked to refer to the four-point rating scale that was also used for the motor and perceptual-cognitive domain items. For the evaluation of the future performance level, coaches rated on a three-point rating scale: professional (League 1–3) (1); semi-professional (League 4–5) (2); or amateur (League 6 or lower) (3). These ratings referred to the highest division that the player was expected to play in adulthood and reflect a commonly used categorization for adult performance level in Germany (e.g., see Höner et al., 2017).

To determine the relative age of the players, the birth dates of players were assessed. Beyond that, the *height* and *weight* of the players were measured as an indicator for physical development. Height was determined to the nearest 1 cm using a fixed stadiometer, while weight was measured to the nearest 0.1 kg using calibrated scales.

Statistical Analyses

Data were analyzed using SPSS version 26 and Mplus version 8.2. The level of significance for all statistical procedures was set to $\alpha = 0.05$. The data from the three seasons were aggregated for each age group. If a player had participated in the assessment more than once, only the data from their first assessment were considered.

The five objective tests of motor diagnostics assessed speed abilities and technical skills. Höner et al. (2015) showed that these tests contain a two-factorial structure reflecting the two performance parameters—i.e., *speed abilities* and *technical skills.* While sprint and agility significantly loaded on speed abilities, ball control and juggling loaded on technical skills. Dribbling however simultaneously loaded on both speed and technical skills, and therefore, it was assigned to both factors. The measurement model for the factor technical skills in the study of Höner et al. (2015) also included the score from a test of shooting; however, it was no longer part of the diagnostic test at the time of the present study due to issues concerning the reliability of the test. Therefore, a further confirmatory factor analysis was performed to recheck the two-factorial structure of the tests. While the measurement model for speed abilities stayed the same (i.e., measured by sprint, agility, and dribbling), the measurement model for technical skills remained restricted to the tests for dribbling, ball control, and juggling.

TABLE 2 | Descriptive statistics for the study sample separated by age group ($N = 16{,}138$).

Age group	n	Relative age (week of birth within year)		Anthropometric assessments		Objective motor diagnostic		Subjective evaluation (domain-specific)			Subjective evaluation (holistic)						
						Performance factor											
				Height (cm)	Weight (kg)	Speed abilities#	Technical skills#	Kicking skills	Tactical skills	Psychosocial skills	Current performance level				Future performance level		
											(0)	(1)	(2)	(3)	League 1–3	League 4–5	≤League 6
		M (SD)	Mdn	M (SD)							n (% per age group)						
U12	8,267	23.22 (14.51)	22.00	150.58 (7.05)	39.00 (5.81)	−0.29 (0.83)	−0.30 (0.67)	1.38 (0.57)	1.51 (0.60)	1.76 (0.67)	389 (4.7)	3,816 (46.2)	3,391 (41.0)	671 (8.1)	683 (8.3)	3,597 (43.5)	3,987 (48.2)
U13	4,033	23.32 (14.44)	23.00	156.86 (7.82)	43.72 (6.71)	0.08 (0.79)	0.10 (0.70)	1.42 (0.56)	1.53 (0.59)	1.77 (0.66)	175 (4.3)	1,893 (46.9)	1,654 (41.0)	311 (7.7)	263 (6.5)	1,779 (44.1)	1,991 (49.4)
U14	2,489	22.46 (14.65)	21.00	164.87 (8.70)	50.83 (8.32)	0.44 (0.80)	0.46 (0.73)	1.41 (0.56)	1.52 (0.58)	1.78 (0.68)	81 (3.3)	1,244 (50.0)	1,008 (40.5)	156 (6.3)	135 (5.4)	1,125 (45.2)	1,229 (49.2)
U15	1,349	21.77 (14.58)	20.00	172.21 (7.81)	58.79 (8.52)	0.70 (0.79)	0.68 (0.76)	1.51 (0.54)	1.62 (0.56)	1.81 (0.65)	39 (2.9)	576 (42.7)	624 (46.3)	110 (7.7)	89 (6.6)	659 (48.9)	601 (44.6)

#Test results for speed abilities and technical skills are displayed as Z-scores.

As a result, there was an acceptable model fit for the data from the present study [$\chi^2_{(3)} = 406.19$, $p < 0.001$, root mean square error of approximation (*RMSEA*) = 0.09, comparative fit index (*CFI*) = 0.97, standardized root mean square residual (*SRMR*) = 0.03]. In the following, the unstandardized factor loadings for the individual tests resulting from the confirmatory factor analyses served to estimate factor scores for each individual with respect to speed abilities and technical skills. The maximum *a posteriori* regression method was implemented in Mplus as a standard procedure for factor score estimation (see Muthén and Muthén, 2017). Test performances that were measured by time (i.e., sprint, agility, dribbling, and ball control) were inverted so that a higher factor score (in *z*-values) represented better performance.

To investigate the RAE, bivariate Pearson correlations were calculated and classified in accordance with Cohen (1988). Relative age was determined on two scales, i.e., birth month and weeks. Because week 53 of the year is shorter than the other weeks, this would have affected the birth frequency per week, and therefore, the *extent of the RAE* was investigated regarding birth frequencies per month. Pearson correlation coefficients between the birth month and frequency of players born in the respective month served as measures for a potential linear decrease of birth rates from early- to late-born players within each age group. Moreover, odds ratios for being selected for the talent promotion program for players born in the first quarter of the year (Q1: January–March) compared with players born in the fourth quarter of the year (Q4: October–December) were reported (under the assumption that birth frequencies were equally distributed among birth quarters in the underlying population).

The age-related biases in the objective and subjective assessments of the performance factors were determined by calculating the Pearson correlations and the corresponding 95% confidence intervals in two considerations. First, correlations between the relative age of players (using birth week) and each assessment score were computed. These correlation analyses[3] were conducted separately within each age group (i.e., U12, U13, U14, and U15) and, second, compared with the omnibus correlation between the chronological age of players (i.e., age to the nearest 0.01 years) with each of the assessments across the total sample. To determine the size of a possible population effect, sensitivity was calculated by *post-hoc* power analysis using G*Power version 3.1.9.7. Accordingly, analysis of the age group comprising the lowest sample size (i.e., U15, $n = 1{,}349$) determined the sensitivity to be equal to $r = 0.08$ ($\alpha = 0.05$, $1 - \beta = 0.85$, two-tailed). Therefore, even small effect sizes could be detected within the present study. Because the aggregation of the different individual motor tests to the factors speed abilities and technical skills might have potentially hidden some relationships between relative age and performance on those individual tests, correlations between birth week and each motor test were also calculated.

[3]To check for a potential change in the correlations by the added variability when using birth weeks, correlations were additionally computed for birth months. As there was no distinct change in the correlations, only those for the more detailed approach (that is, birth weeks) were reported.

Regarding the *coaches' holistic ratings*, the associations between relative age and the relative frequency (per birth week) of players who were evaluated as highly talented, i.e., assigned to (a) at least the level of the extended squad for regional association team (current performance level score ≥ 2) or to (b) professional adult level (future performance level score $= 1$), were investigated by correlation analyses.

RESULTS

Descriptive statistics for each of the player characteristics are displayed in **Table 2**, shown separately for each of the four age groups.

When considering the relative age of the players within each age group, **Table 2** shows a trend for an overrepresentation of players born earlier within the selection year ($M \leq 23.32$ for all age groups with regard to the week of birth within the year), which is also reflected in the odds ratios for players born in Q1 compared with those born in Q4 (U12: $OR = 1.85$; U13: $OR = 1.88$; U14: $OR = 2.16$; U15: $OR = 2.37$). **Figure 1** confirms this, demonstrating the birth distribution of all players in each age group. In all age groups, a decrease is seen in birth frequencies from players born earlier to players born later in the year. Indeed, highly significant negative correlations are found between the birth frequency and relative age in all age groups ($-0.92 \leq r \leq -0.95$, each $p < 0.001$).

Figure 2 shows the relationship between the relative age of the players and their anthropometric assessments (**Figure 2A**), their objective motor diagnostics (**Figure 2B**), and their domain-specific subjective evaluations (**Figure 2C**). Regarding the anthropometric assessments, a systematic increase in the height and weight of the players is seen with age both within and across the age groups. These descriptive findings are confirmed by significant but small correlations within each age group for height ($0.21 \leq |r| \leq 0.26$, each $p < 0.001$) and weight ($0.18 \leq |r| \leq 0.23$, each $p < 0.001$, see **Table 3**). However, these correlations were weaker than the associations found between chronological age and height ($|r| = 0.70$, $p < 0.001$) and with weight ($|r| = 0.69$, $p < 0.001$), when examined across all age groups.

With respect to the objective motor diagnostics, **Figure 2B** shows the results for speed abilities and technical skills as a function of the relative ages of the players. While there is a noticeable increase in both speed abilities and technical skills when considered across all ages in the cohort (speed abilities $r = 0.38$, $p < 0.001$; technical skills $r = 0.43$, $p < 0.001$), any increases *within* the age groups are less distinct ($0.04 \leq |r| \leq 0.06$). This results in a striking stepwise pattern whereby there is little difference in the speed abilities of the players within the U12 to U15 age groups and even less difference in their technical skills, yet there is a considerable difference as a result of age *between* the successive age groups. When examining the results on the individual motor tests, the relationship with relative age was weak for the 20-m sprint ($0.10 \leq |r| \leq 0.18$ within age groups) and negligible for the other tests ($|r| \leq 0.06$).

Figure 2C shows the relationship between the relative ages of the players and the subjective evaluations of their kicking, tactical, and psychosocial skills. Trivial-to-weak trends were found within age groups, with higher ratings of older players found in all four age groups for each of the three parameters. In line with this, correlation analyses revealed significant, but trivial-to-small Pearson coefficients within age groups for kicking skills ($0.06 \leq |r| \leq 0.11$, each $p < 0.001$) and tactical skills ($0.04 \leq |r| \leq 0.10$, each $p < 0.05$). Correlations between relative age and psychosocial skills were even lower ($0.01 \leq |r| \leq 0.05$) and non-significant within the older age groups (U14 and U15). Omnibus correlations performed across all participants revealed only trivial associations between age and kicking skills ($|r| = 0.07$, $p < 0.001$), tactical skills ($|r| = 0.05$, $p < 0.001$), and psychosocial skills ($|r| = 0.03$, $p < 0.001$), suggesting only very small increases in the subjective evaluations with age.

An inspection of the holistic ratings of current and future performance provided by the coaches (**Table 2**) shows that the coaches predominantly categorized current performance as either being at the CC level (score 1) or of the extended squad for regional association teams (score 2) and predominantly categorized future performance either at League 4–5 level or lower.

Figures 3, **4** show the relative frequencies of the holistic ratings per week of birth specifically for the higher levels of current performance (that is, extended squad or the core team for regional association team in combination; level scores 2 or 3, respectively) and future performance (i.e., League 1–3). Except for U14, moderate-to-strong associations were found whereby earlier-born players were more likely to be higher ranked for both their current and future performance. In other words, earlier-born players were more likely to have their current performance rated as being in the extended or core squad of a regional association team ($-0.65 \leq r \leq -0.48$, each $p < 0.01$). Likewise, earlier-born players were more likely to be predicted to reach the professional level (League 1–3) in the U12 ($r = -0.48$, $p < 0.001$), U13 ($r = -0.36$, $p < 0.01$), and U14 ($r = -0.32$, $p < 0.05$) age groups.

DISCUSSION

Within research on talent development, the RAE is a well-known and widely studied phenomenon (Roberts et al., 2020). Knowledge about the extent of RAEs as well as the magnitude of age-related biases in these assessments is of particular importance to support an efficient and fair talent development strategy. Thus, the present study helps to improve our understanding of how the selection of talented players is biased by their relative age. Beyond that, the study provides evidence about the degree to which both objective *and* subjective assessments of talented players are biased by their relative age. Further, identified gaps in research on RAEs in sport were addressed (e.g., Roberts et al., 2020; Webdale et al., 2020). We employed a cohort study design using a large sample of highly talented soccer players to detect nuances in RAEs (Romann et al., 2018; Bergkamp et al., 2019) across age groups (i.e., U12 to U15) that are critical in the process of youth athlete development. Due to the large sample size, it was possible to compare the performance level of the players based

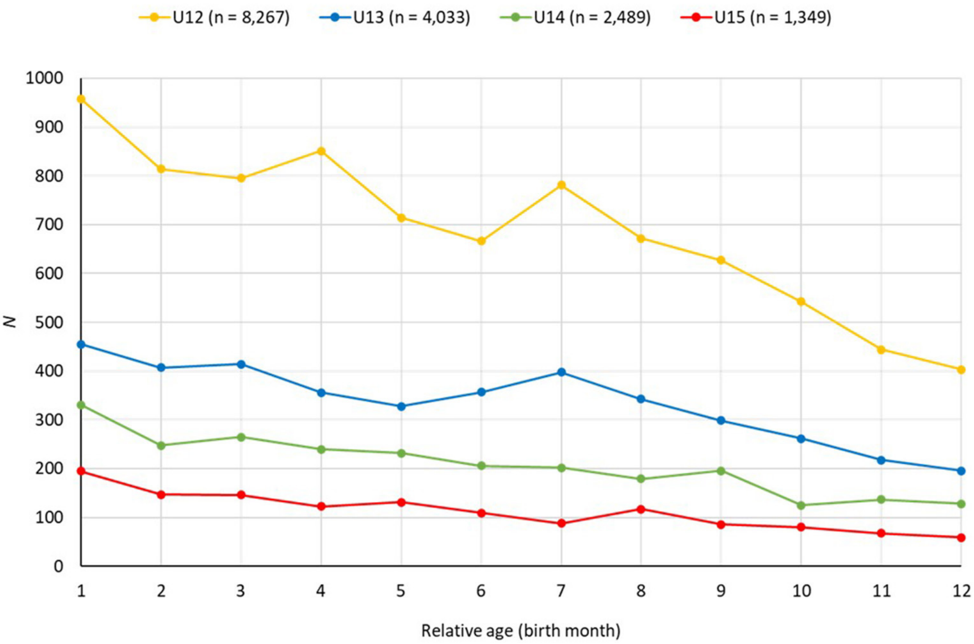

FIGURE 1 | Birth distribution of players in the age groups U12 to U15 according to their relative age (birth month).

on the weeks they were born in within a year, allowing for a more differentiated, sensitive, and less aggregative analysis that goes beyond the analysis of year quartiles (Cumming et al., 2018; Roberts et al., 2020). Furthermore, the present study followed the recommendation of Ford et al. (2020) and Williams et al. (2020) by examining age-related biases using a multidimensional design that canvassed a range of performance characteristics whose prognostic relevance in soccer has been confirmed (Höner et al., 2017, in revision). In addition, coach ratings of the current and future performance level of the players allowed an examination of biases in a way that coaches holistically judged the talent of the players.

Extent of Relative Age Effect

The high correlations between the birth frequency and relative age in all four birth cohorts ($0.92 \leq |r| \leq 0.95$) confirm the presence of the RAE in our cohort and are consistent with the findings of previous research on RAEs in preselected samples of talented athletes, including players involved in nationwide talent promotion programs (Lovell et al., 2015; Romann et al., 2020), youth academy players (Augste and Lames, 2011; Parr et al., 2020), youth national team players (Höner et al., 2017), and adults at a professional level (Helsen et al., 2005; Doyle and Bottomley, 2018). Although the overrepresentation of players born earlier in the year was found for CC players within the present study (average birth week between 21.7 and 23.2, $20 \leq$ $Mdn \leq 23$, depending on age class), the magnitude of the effect was smaller than that sometimes reported previously in studies that have examined higher levels of performance. For instance, Parr et al. (2020) reported that 77% of players within 84 English youth academies (U12 to U16) were born within the first half of the selection year, with the average player born in week 17.3. Furthermore, larger RAEs were reported by Schroepf and Lames (2018) in U16 youth national teams (Mdn = week 12). Among other explanations, this might be because coaches of higher selection levels experience more pressure for current (instead of future) success in competition and, thus, may be more likely to select older players with potentially higher current performance levels (Votteler and Höner, 2017; Götze and Hoppe, 2021).

In the present study, the magnitude of the RAE increased marginally from week 23.2 in the U12 age group to week 21.7 in the U15 age group. This also aligns with previous literature. The RAE is already present in the first selections for a talent promotion program or youth academy in early adolescence (Romann et al., 2020). This overrepresentation of older athletes remains at a high level from early to middle adolescence (Votteler and Höner, 2017; and found in the present study) and decreases but is still present in older age classes or adulthood (Höner et al., 2017; Doyle and Bottomley, 2018).

Relative Age-Related Biases in Objective and Domain-Specific Subjective Diagnostics

The current study objectively assessed the anthropometric characteristics of players (i.e., height and weight) along with their speed and technical skills by using established diagnostics that are objective and reliable, and it added subjective evaluations of kicking, tactical, and psychosocial skills using validated scoring methods.

Regarding the *anthropometric parameters*, strong associations were found across all participants when examining the

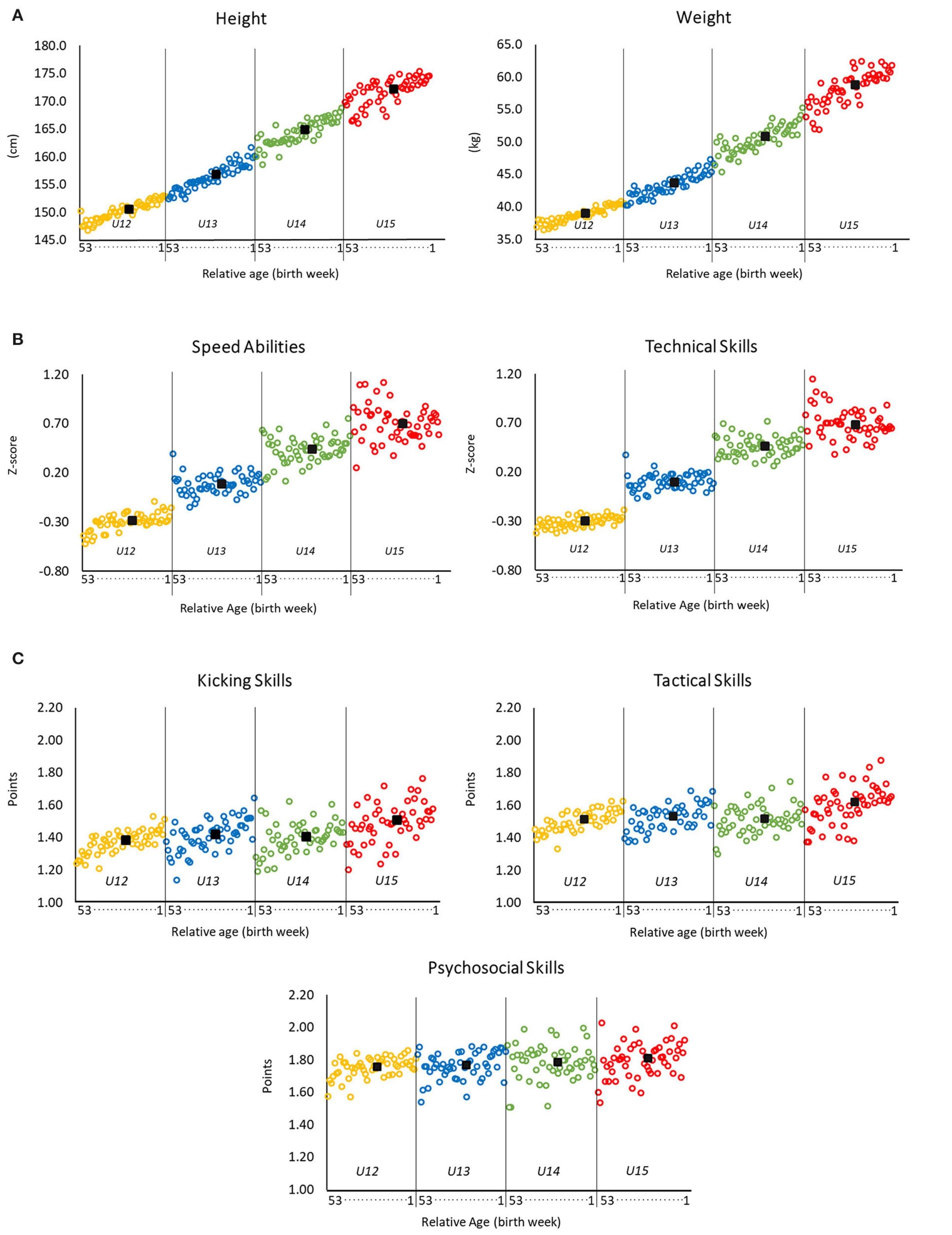

FIGURE 2 | Players' height and weight **(A)**, players' test performances in the objective motor diagnostics **(B)**, and test results for the subjective evaluations by coaches **(C)** as a function of relative age (in weeks) ordered by chronological age. Within age groups, results are displayed by increasing relative age (that is, from players born in week 53 within the year to players born in week 1 within the year). Black squares represent the mean value for the respective age group.

correlation between the ages of the players and their height ($r = 0.70$) and weight ($r = 0.69$). These results are of course not surprising and are in line with the normal development curve expected as a result of physical development during puberty (e.g., Mendez-Villanueva et al., 2016). Indeed, Parr et al. (2020) found similar correlations in their study of English youth academy players in comparable age groups (U12 to U16) for both height ($r = 0.78$) and weight ($r = 0.81$). However, when looking at the relationships between physical characteristics and relative age *within* each age group in our study, correlations were still present but distinctly lower for both parameters ($0.18 \leq r \leq 0.26$). Although Parr et al. (2020) did not consider age groups separately, the authors analyzed correlations of relative age for the total sample and found even lower relationships (height: $r = 0.14$, weight: $r = 0.17$). Similarly, Deprez et al. (2012) found a trend for taller and heavier players born in the first birth quarter in U10 to U19 elite soccer players in Belgium. The current study's results are most comparable to those of a study by Votteler and Höner (2014), who investigated relative age-related biases in objective performance diagnostics using the same test battery and anthropometric data assessments as the present study, but in a different player cohort. Votteler and Höner found correlations with similar magnitudes to the present study when controlling for age group (height: $r = 0.20$; weight: $r = 0.18$).

The results for the *objective diagnostics of motor performance* (i.e., speed abilities and technical skills) reveal a different pattern of results. Moderate correlations were found with age for speed abilities ($r = 0.38$) and technical skills ($r = 0.43$) across all ages from U12 to U15; however, correlations almost disappeared when examining each age group separately ($r_s < 0.06$). Presumably, the motor performance of each player developed systematically with age from U12 to U15. However, the association between age and motor performance was almost absent *within* the age groups, with almost no difference in performance between the early- and late-born players. This led to a "stepwise function" when examining the relationship between age and both speed abilities and technical skills (see **Figures 2A,B**; see also Votteler and Höner, 2014). The findings within age groups are consistent with those by Lovell et al. (2015), who found trivial-to-small advantages in the agility of earlier-born U12 ($d = 0.21$) and U14 ($d = 0.08$) players when compared with their younger counterparts in a sample of talented players selected for English soccer development programs. Equally, Parr et al. (2020) did not find relationships between the relative ages of elite academy soccer players and their speed of change of direction ($r = 0.08$), and only small correlations for 20-m sprint performance ($r = 0.19$) within age groups. Peña-González et al. (2018) did not find significant differences within age groups (U12, U14) in 30-m sprint and agility. Similar results were found for soccer-specific technical skills (i.e., ball control, dribbling speed, passing, and shooting) in a study of 11- and 13-year-old male Portuguese club-level soccer players (Figueiredo et al., 2019).

The stepwise pattern seen in **Figure 2B** represents a form of *Simpson's paradox*, whereby the pattern seen within the groups is inconsistent with (or would otherwise be hidden by) the overall pattern across all groups. Within the classic Simpson's paradox, a trend seen within individual groups disappears or is reversed when the groups are combined (Kievit et al., 2013). This is indeed seen in **Figure 2B**, and the findings help to reveal important insights into the RAE. Speed and technical skills do indeed improve with age; this is confirmed by the strong associations found when examining participants across all ages. However, the very weak associations within the age groups are consistent with the idea that the speed and technical skills of the later-born children need to be at least as good as those of the older-born children to be selected into the talent promotion program at the CCs. Later-born children may be less likely to be included in the program, even if their speed and/or technical skills were to be just as good as the skills of the earlier-born children would have been at the same age (i.e., up to 12 months earlier). Roberts et al. (2020) highlighted that the physical ability of younger players might need to be superior to compensate for potential developmental disadvantages (Wattie et al., 2008). In that sense, younger players must invest, for example, in their development of speed abilities and/or technical or tactical skills to compensate for their disadvantages in terms of age and body composition (Ford and Williams, 2012). Thus, a minimum level of speed abilities and technical skills is required, and presumably, only outstanding younger kids are being selected. As a result, younger players who may reach that level if given equal time to develop (as the older kids) might be unfairly excluded.

In fact, there is some evidence that the later-born children sometimes possess better speed and technical skills than the earlier-born children, especially in the older age groups. **Figure 2B** shows that the best-performing children in the U13–U15 age groups, for both speed and technical skill, are almost always among the later born. These findings may help to explain why the magnitude of RAEs eventually decreases toward adulthood: already at the U13 level, the best-performing players, in terms of speed and technical skill, are those later-born children who are within the talent pathway and presumably who may end up more likely to reach the elite level. These, often called high-performing "underdogs," might have higher probabilities to succeed in the long term if they can survive within the talent promotion pathway (e.g., Kelly et al., 2020).

The pattern of findings for the subjectively assessed *domain-specific performance factors* (i.e., kicking, tactical, and psychosocial skills) were expected to be different to the objective tests given that coaches were required to rate players relative to others in their age group. Referring to the relationship between chronological age and the subjective performance ratings across all age groups, coefficients ($|r| < 0.07$) indicate only small associations. This confirms that coaches were to some extent successful in their ability to rate their players with reference to their specific age group. Regarding the results *within* the age groups, relationships between relative age and all subjective assessments were also rather low. This holds especially true for psychosocial skills ($0.01 \leq |r| \leq 0.05$), i.e., a domain that has only an indirect relationship with the soccer skills of the players. It remains unclear what the relationship within age groups would have been if examined in an unbiased, not preselected population. Presumably, a positive relationship would exist given

TABLE 3 | Correlations (r_{xy}) between players' relative age (in weeks) and anthropometric data, objectively as well as subjectively assessed domain-specific performance factors separated by age group.

Age group	*n*	Anthropometric assessments		Objective motor diagnostic		Subjective evaluation (domain-specific)			Subjective evaluation (holistic)	
		Height	Weight	Performance factor						
				Speed abilities	Technical skills	Kicking skills	Tactical skills	Psychosocial skills	Current performance level	Future performance level
				r_{xy} with relative age (Pearson)[#] [95% CI]					r_s with relative age (Spearman) [95% CI]	
U12	8,267	−0.21*** [−0.23; −0.19]	−0.18*** [−0.20; −0.16]	−0.06*** [−0.08; −0.04]	−0.04*** [−0.06; −0.02]	−0.08*** [−0.10; −0.06]	−0.08*** [−0.10; −0.06]	−0.03** [−0.05; −0.01]	−0.07*** [−0.09; −0.05]	0.07*** [0.05; 0.09]
U13	4,033	−0.26*** [−0.29; −0.23]	−0.22*** [−0.25; −0.19]	−0.04* [−0.07; −0.01]	−0.02 [−0.05; 0.01]	−0.11*** [−0.14; −0.08]	−0.07*** [−0.10; −0.04]	−0.05** [−0.08; −0.02]	−0.07*** [−0.10; −0.04]	0.06*** [0.03; 0.09]
U14	2,489	−0.22*** [−0.26; −0.18]	−0.20*** [−0.24; −0.16]	−0.06** [−0.10; −0.02]	0.01 [−0.03; 0.05]	−0.06*** [−0.10; −0.02]	−0.04* [−0.08; 0.00]	−0.01 [−0.05; 0.03]	−0.05** [−0.09; −0.01]	0.04* [0.00; 0.08]
U15	1,349	−0.21*** [−0.26; −0.16]	−0.23*** [−0.28; −0.18]	0.03 [−0.02; 0.08]	0.04 [−0.01; 0.09]	−0.10*** [−0.15; −0.05]	−0.10*** [−0.15; −0.05]	−0.05 [−0.10; 0.00]	−0.09** [−0.14; −0.04]	0.08** [0.03; 0.13]
				r_{xy} with chronological age (Pearson) [95% CI]					r_s with chronological age (Spearman) [95% CI]	
Total	16,138	0.70*** [0.69; 0.71]	0.69*** [0.68; 0.70]	0.38*** [0.37; 0.39]	0.43*** [0.42; 0.44]	0.07*** [0.06; 0.09]	0.05*** [0.04; 0.07]	0.03*** [0.02; 0.05]	0.03*** [0.02; 0.05]	−0.01 [−0.03; 0.01]

**p* < 0.05; ***p* < 0.01; and ****p* < 0.001.

[#]*A negative correlation coefficient concerning relative age represents a higher test result for earlier-born players.*

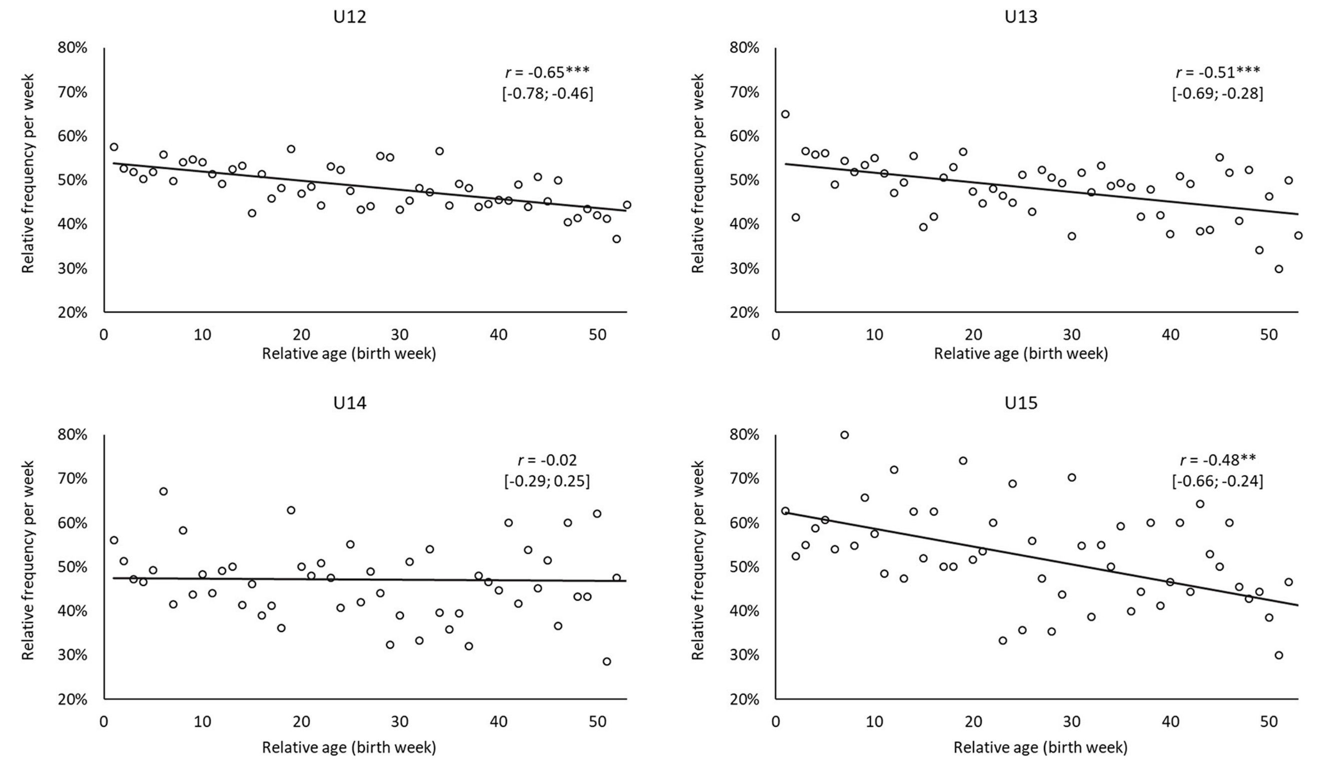

FIGURE 3 | Relative frequencies for holistic ratings of current player performance per week of birth for players whose current performance was assigned to the level of the extended squad (Level 2) or the core team for regional association (Level 3) by coaches for the age groups U12 to U15. $p < 0.05$; $^{**}p < 0.01$; and $^{***}p < 0.001$.

that kicking skills, tactical skills, and psychosocial skills would be expected to improve with age. However, it is not clear what would be the magnitude of those relationships in comparison with those we found in our study. If these three sets of skills were to be important for selection in the program, then the correlations in our group should be expected to be weaker than those that would exist for the wider population.

Relative Age-Related Biases in Holistic Subjective Evaluations

Coaches rated only a small proportion of the players in the best categories for their current (6.3–8.1%) and future (5.4–8.3%) performance. Höner and Votteler (2016) state, in their study examining the prognostic relevance of motor talent predictors in early adolescence, that 4.1% of the U12 CC players of the German talent promotion program belonged to one of the regional association teams. Accordingly, it can be assumed that the evaluation of the CC coaches is too high. That is, they may overestimate the ability of the players in their group. Similarly, Höner et al. (2017) found in a prospective study that only 0.6% of the U12 CC players of the German talent promotion program born between 1993 and 1995 ultimately achieved a contract with a club from the top three German soccer leagues in adulthood. However, only the 2014/2015 season was investigated in that study, and thus, a higher transition rate might be expected when considering more than one season. Nevertheless, it can be assumed that the CC coaches' holistic ratings of the players' future performance level were also probably optimistic. Thereby, both the rather similar proportions of players who were rated in the best categories for both their current *and* future performance level and the high correlations between these two evaluations in each age group ($0.63 \leq |r| \leq 0.69$) indicate that coaches' ratings on current performance might have also contributed to that of *future* performance. Therefore, coaches did not consider those two holistic assessments independently. Furthermore, separate analyses for players born in Q1 ($0.64 \leq |r| \leq 0.69$) revealed similar correlations to those for players born in Q4 ($0.60 \leq |r| \leq 0.74$). This might imply that coaches could even reinforce considering age-related information in their ratings in order to optimize the evaluation of players' future potential.

Regarding relative age-related biases, a considerable relationship was found between the relative age of the players and the holistic assessments of their current and expected future levels of performance. Here, the trend toward a better rating for earlier-born players is in line with the results of Peña-González et al. (2018), who assessed a holistic measure of the efficacy of soccer players. However, the results contrast with the lack of any advantage found for players born in the first half of the year when coaches rated the in-game performance of players (Hill et al., 2020). In contrast, an age-related bias was reported by Figueiredo et al. (2019) when examining a holistic rating of player potential.

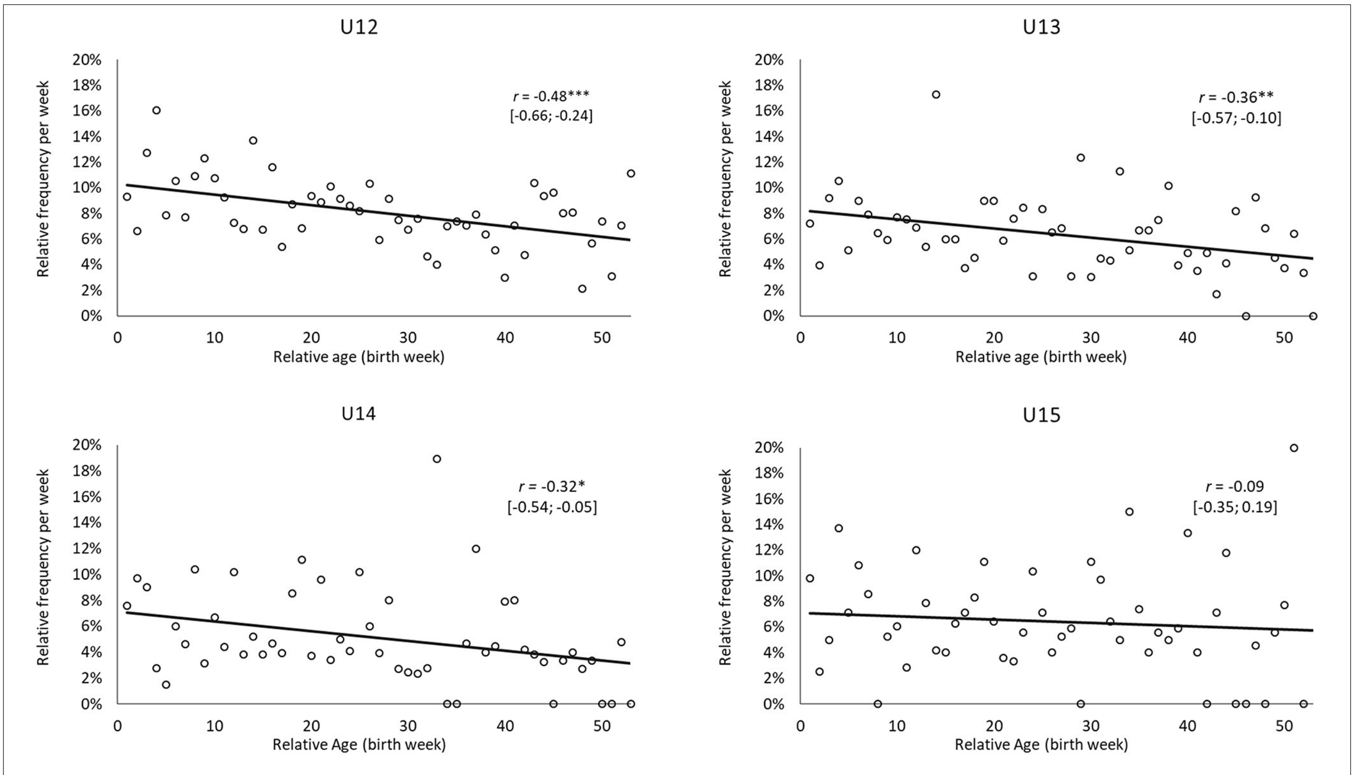

FIGURE 4 | Relative frequencies for holistic ratings of future performance per week of birth for players whose future performance was assigned to the professional level (League 1–3) by coaches for the age groups U12 to U15. $p < 0.05$; $^{**}p < 0.01$; and $^{***}p < 0.001$.

This perspective is particularly relevant for coaches and scouts because this refers to key points within the talent identification and development process (e.g., older players are expected to be more likely to perform at a higher level now and in the future). Interestingly, coaches' holistic ratings reveal a significant bias within the age groups U12 to U14 to rate earlier-born players as better ($0.32 \leq |r| \leq 0.48$). Accordingly, the coaches' ratings are in conflict with the underdog hypothesis, at least within the German talent promotion program. The late-born players who were selected for the program were shown to have—in relation to their age—advanced abilities and skills enabling them to compete with their older counterparts with the same age group. Even those players were rated by the coaches as being less likely to play at the highest level not only in the present but also at the professional level in adulthood.

Limitations

Although the present study is characterized by several unique features (i.e., large sample of highly talented players within a nationwide talent promotion program, multidimensional objective and subjective domain-specific as well as holistic assessments), several limitations must be addressed. First, the results were biased in that a preselected sample was investigated, meaning that the later-born players in our sample were predominantly those who might have been exceptionally talented, with weaker players more likely to have not be selected or be dropped from the program (Parr et al., 2020). As noted, later-born children were under-represented in our sample, and those who were included were likely to have been even more talented than the older athletes if they were each to be assessed at the same chronological age.

Second, differences in the biological maturity of the players might have affected the findings. While the present study only revealed a limited association between relative age and performance within the age groups, this could also be explained by an overrepresentation of earlier maturing athletes in the later-born athletes. Whereas, chronological/relative and biological age are often described as dependent effects within talent development such that the differences in biological age at least in part explain RAEs (i.e., on average, older players are also biologically older), indeed, both constructs, relative and biological age, must be separated from each other (Hill et al., 2020; Roberts et al., 2020). Given this, a perspective for future research is certainly to address both relative *and* biological age to adequately provide players, but also coaches, with important information about player development. While the present study was conducted within a nationwide talent promotion program and only measured height and weight as indicators for physical development, no explicit information referring to biological maturity status was assessed. Here, recent research highlights the usefulness of multiple pragmatic assessment methods of biological maturity in broader contexts (Leyhr et al., 2020). Such approaches facilitate the integration of bio-banding strategies—a hot topic in talent research—within training practice and competition but must be further investigated concerning its effectiveness within talent development environments (Cumming et al., 2018; Towlson et al., 2020).

Third, *female participants* were not investigated within the present study. Indeed, the majority of studies within talent research are conducted with male athletes (Murr et al., 2018; Baker et al., 2020). However, given the increasing popularity of female soccer (Manson et al., 2014), but also the fact that conclusions drawn from male athletes cannot necessarily be transferred to females (Williams and Reilly, 2000), it is essential to extend future research regarding relative age-related biases in assessments of performance factors also to females.

Finally, the present study utilized a cross-sectional design to examine associations with relative age in the age groups U12 to U15. While only the first measurement point for each player was considered within the present study, a *longitudinal design* might have enabled further insights into players' individual development (Neubauer and Schmiedek, 2020) and into how potential changes in the magnitude of RAEs with age are associated with the diagnostic results.

Conclusion and Practical Implications

The present research provides empirical evidence for the extent of the RAE in a preselected sample of highly talented youth soccer players. Furthermore, consistent with the call for multidimensional approaches that incorporate objective, but also subjective assessments of talent (Ford et al., 2020; Williams et al., 2020), insights were given into the relative magnitudes of age-related biases in a variety of measures of performance. While an overrepresentation of earlier-born players was confirmed in the preselected sample, the relationship between relative age and all performance factors within each age group was rather low. However, this was not the case for the anthropometric measures that would be less likely to be associated with future performance (i.e., height and weight). This leads to the conclusion that the performance of most of the later-born players was advanced relative to their age, sometimes to the point where it was *better* than that of their earlier-born counterparts. Assuming an equal distribution of soccer talent irrespective of whether they were born in the first or last week of the year, the findings provide an indication that later-born players must be more advanced in terms of their soccer-specific skills, or that they must invest more to stay in the talent promotion system, than those born earlier in the year. In terms of practical implications, this finding can be used to further raise the awareness of the RAE for coaches and administrators involved in the subjective selection and evaluation of players, as well as in the interpretation of the results of motor diagnostics.

Because the relationships with relative age within age groups were comparable across all performance factors, the present study does at least not support the assumption by Lund and Söderström (2017) that subjective assessments might be more biased by relative age than objective assessments. Despite some disadvantages, subjective assessments are beneficial for the assessment of complex skills such as kicking, tactical, and psychosocial skills, because they are difficult to measure objectively performance within a nationwide talent promotion program (Höner et al., in revision). In integrating both objective and subjective measurements that cover a variety of performance factors, coaches are provided with information useful for monitoring player development. However, the detected biases within the holistic performance level ratings reinforce the necessity for coaches to be aware of the relative age-related biases and the optimism of their ratings.

The presence of the RAE within the study sample, and the results concerning the magnitude of relative age-related biases, highlights the need for strategies to reduce the influence of relative age on talent selection and development. Webdale et al. (2020) reviewed studies that proposed strategies to solve the relative age problem in sport, addressing both player selection and the use of performance assessments. Raising the awareness of RAEs with coaches and scouts has seemed a promising approach, though the efficacy so far is questionable (Mann, 2020). On the one hand, Hill and Sotiriadou (2016) showed that coaches' awareness of the RAE could not reduce biases in decisions during the selection of talent in 12- to 15-year-old players. On the other hand, Mann and van Ginneken (2017) revealed that age-ordered shirt numbering, an explicit cue of differences in age, reduced the selection biases of professional soccer scouts. Webdale et al. (2020) highlighted the potential to use tests that focus on technical and tactical skills that are presumably predictive of performance that are less biased by the players' relative age. However, the measures of technical and tactical skill in the present study were no less biased by relative age than the other measures. In contrast, the stepwise function seen for these variables across age indicates that later-born children have advanced technical skills when compared with what would be expected for their actual chronological age.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the university's ethics department and the scientific board of the DFB. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

DL and OH: conceptualization and methodology. DM, OH, DL, FB, RS, and DD: writing—review, editing, and investigation. DL, FB, RS, and OH: validation, visualization, and writing—original draft. OH: project administration, funding acquisition, data curation, and supervision. DL: formal analysis. All authors contributed to the article and approved the submitted version.

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REFERENCES

Augste, C., and Lames, M. (2011). The relative age effect and success in German elite U-17 soccer teams. *J. Sports Sci.* 29, 983–987. doi: 10.1080/02640414.2011.574719

Baker, J., Steingröver, C., Wong, H., Cobley, S., and Schorer, J. (2014). Variations in relative age effects in individual sports: skiing, figure skating and gymnastics. *Eur. J. Sport Sci.* 14(Suppl. 1), S183–S190. doi: 10.1080/17461391.2012.671369

Baker, J., Wilson, S., Johnston, K., Dehghansai, N., Koenigsberg, A., de Vegt, S., et al. (2020). Talent research in sport 1990-2018: a scoping review. *Front. Psychol.* 11:607710. doi: 10.3389/fpsyg.2020.607710

Bergkamp, T., Niessen, A., den Hartigh, R., Frencken, W., and Meijer, R. (2019). Methodological issues in soccer talent identification research. *Sports Med.* 49, 1317–1335. doi: 10.1007/s40279-019-01113-w

Buekers, M., Borry, P., and Rowe, P. (2015). Talent in sports. Some reflections about the search for future champions. *Movem. Sport Sci.* 88, 3–12. doi: 10.1051/sm/2014002

Castillo, D., Pérez-González, B., Raya-González, J., Fernández-Luna, Á., Burillo, P., and Lago-Rodríguez, Á. (2019). Selection and promotion processes are not associated by the relative age effect in an elite Spanish soccer academy. *PLoS ONE* 14:e0219945. doi: 10.1371/journal.pone.0219945

Cobley, S., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Cumming, S., Searle, C., Hemsley, J., Haswell, F., Edwards, H., Scott, S., et al. (2018). Biological maturation, relative age and self-regulation in male professional academy soccer players: a test of the underdog hypothesis. *Psychol. Sport Exerc.* 39, 147–153. doi: 10.1016/j.psychsport.2018.08.007

Deprez, D., Coutts, A. J., Fransen, J., Deconinck, F., Lenoir, M., Vaeyens, R., et al. (2013). Relative age, biological maturation and anaerobic characteristics in elite youth soccer players. *Int. J. Sports Med.* 34, 897–903. doi: 10.1055/s-0032-1333262

Deprez, D., Vaeyens, R., Coutts, A. J., Lenoir, M., and Philippaerts, R. (2012). Relative age effect and Yo-Yo IR1 in youth soccer. *Int. J. Sports Med.* 33, 978–993. doi: 10.1055/s-0032-1311654

Diamantopoulos, A., Sarstedt, M., Fuchs, C., Wilczynski, P., and Kaiser, S. (2012). Guidelines for choosing between multi-item and single-item scales for construct measurement: a predictive validity perspective. *J. Acad. Mark. Sci.* 40, 434–449. doi: 10.1007/s11747-011-0300-3

Doyle, J., and Bottomley, P. (2018). Relative age effect in elite soccer: more early-born players, but no better valued, and no paragon clubs or countries. *PLoS ONE* 13:e0192209. doi: 10.1371/journal.pone.0192209

Duarte, J., Coelho-e-Silva, M., Costa, D., Martinho, D., Luz, L., Rebelo-Gonçalves, R., et al. (2019). Repeated sprint ability in youth soccer players: independent and combined effects of relative age and biological maturity. *J. Hum. Kinet.* 67, 209–221. doi: 10.2478/hukin-2018-0090

Figueiredo, A., Coelho-e-Silva, M., Cumming, S., and Malina, R. (2019). Relative age effect: characteristics of youth soccer players by birth quarter and subsequent playing status. *J. Sports Sci.* 37, 677–684. doi: 10.1080/02640414.2018.1522703

Ford, P., Hodges, N., Broadbent, D., O'Connor, D., Scott, D., Datson, N., et al. (2020). The developmental and professional activities of female international soccer players from five high-performing nations. *J. Sports Sci.* 38, 1432–1440. doi: 10.1080/02640414.2020.1789384

Ford, P., and Williams, A. (2012). The developmental activities engaged in by elite youth soccer players who progressed to professional status compared to those who did not. *Psychol. Sport Exerc.* 13, 349–352. doi: 10.1016/j.psychsport.2011.09.004

Furley, P., and Memmert, D. (2016). Coaches' implicit associations between size and giftedness: implications for the relative age effect. *J. Sports Sci.* 34, 459–466. doi: 10.1080/02640414.2015.1061198

Gil, S., Badiola, A., Bidaurrazaga-Letona, I., Zabala-Lili, J., Gravina, L., Santos-Concejero, J., et al. (2014). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *J. Sports Sci.* 32, 479–486. doi: 10.1080/02640414.2013.832355

Götze, M., and Hoppe, M. (2021). Relative age effect in elite german soccer: influence of gender and competition level. *Front. Psychol.* 11:587023. doi: 10.3389/fpsyg.2020.587023

Helsen, W., van Winckel, J., and Williams, A. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Hill, B., and Sotiriadou, P. (2016). Coach decision-making and the relative age effect on talent selection in football. *Eur. Sport Manage. Q.* 16, 292–315. doi: 10.1080/16184742.2015.1131730

Hill, M., Scott, S., Malina, R., McGee, D., and Cumming, S. (2020a). Relative age and maturation selection biases in academy football. *J. Sports Sci.* 38, 1359–1367. doi: 10.1080/02640414.2019.1649524

Hill, M., Scott, S., McGee, D., and Cumming, S. (2020b). Are relative age and biological ages associated with coaches' evaluations of match performance in male academy soccer players? *Int. J. Sports Sci. Coaching* 16(2), 227–235. doi: 10.1177/1747954120966886

Hoare, D. G., and Warr, C. R. (2000). Talent identification and women's soccer: an Australian experience. *J. Sports Sci.* 18, 751–758. doi: 10.1080/02640410050120122

Höner, O., and Feichtinger, P. (2016). Psychological talent predictors in early adolescence and their empirical relationship with current and future performance in soccer. *Psychol. Sport Exerc.* 25, 17–26. doi: 10.1016/j.psychsport.2016.03.004

Höner, O., Leyhr, D., and Kelava, A. (2017). The influence of speed abilities and technical skills in early adolescence on adult success in soccer: a long-term prospective analysis using ANOVA and SEM approaches. *PLoS ONE* 12:e0182211. doi: 10.1371/journal.pone.0182211

Höner, O., Murr, D., Larkin, P., Schreiner, R., and Leyhr, D. (in revision). Nationwide subjective and objective assessments of potential talent predictors in elite youth soccer: An investigation of prognostic validity in a prospective study. doi: 10.3389/fspor.2021.638227

Höner, O., and Votteler, A. (2016). Prognostic relevance of motor talent predictors in early adolescence: a group- and individual-based evaluation considering different levels of achievement in youth football. *J. Sports Sci.* 34, 2269–2278. doi: 10.1080/02640414.2016.1177658

Höner, O., Votteler, A., Schmid, M., Schultz, F., and Roth, K. (2015). Psychometric properties of the motor diagnostics in the German football talent identification and development programme. *J. Sports Sci.* 33, 145–159. doi: 10.1080/02640414.2014.928416

Jackson, R., and Comber, G. (2020). Hill on a mountaintop: A longitudinal and cross-sectional analysis of the relative age effect in competitive youth football. *J. Sports Sci.* 38, 1352–1358. doi: 10.1080/02640414.2019.1706830

Johnson, A., Farooq, A., and Whiteley, R. (2017). Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci. Med. Football* 1, 157–163. doi: 10.1080/24733938.2017.1283434

Kalén, A., Lundkvist, E., Ivarsson, A., Rey, E., and Pérez-Ferreirós, A. (2021). The influence of initial selection age, relative age effect and country long-term performance on the re-selection process in European basketball youth national teams. *J. Sports Sci.* 39, 388–394. doi: 10.1080/02640414.2020.1823109

Kelly, A., and Williams, C. (2020). Physical characteristics and the talent identification and development processes in male youth soccer: a narrative review. *Strength Condit. J.* 42, 15–34. doi: 10.1519/ssc.0000000000000576

Kelly, A., Wilson, M., Gough, L., Knapman, H., Morgan, P., Cole, M., et al. (2020). A longitudinal investigation into the relative age effect in an English professional football club: exploring the 'underdog hypothesis'. *Sci. Med. Football* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Kievit, R., Frankenhuis, W., Waldorp, L., and Borsboom, D. (2013). Simpson's paradox in psychological science: a practical guide. *Front. Psychol.* 4:513. doi: 10.3389/fpsyg.2013.00513

Larkin, P., and O'Connor, D. (2017). Talent identification and recruitment in youth soccer: recruiter's perceptions of the key attributes for player recruitment. *PLoS ONE* 12:e0175716. doi: 10.1371/journal.pone.0175716

Leyhr, D., Murr, D., Basten, L., Eichler, K., Hauser, T., Lüdin, D., et al. (2020). Biological maturity status in elite youth soccer players: a comparison of pragmatic diagnostics with magnetic resonance imaging. *Front. Sports Active Living* 2:587861. doi: 10.3389/fspor.2020.587861

López de Subijana, C., and Lorenzo, J. (2018). Relative age effect and long-term success in the spanish soccer and basketball national teams. *J. Hum. Kinet.* 65, 197–204. doi: 10.2478/hukin-2018-0027

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in English lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS ONE* 10:e0137238. doi: 10.1371/journal.pone.0137238

Lund, S., and Söderström, T. (2017). To see or not to see: talent identification in the swedish football association. *Sociol. Sport J.* 34, 248–258. doi: 10.1123/ssj.2016-0144

Mann, D. (2020). "Approaches to help coaches and talent scouts overcome relative age effects," in *Relative Age Effects in Sport,* eds J. C. Dixon, S. Horton, L. Chittle, and J. Baker (New York, London: Routledge), 117–135. doi: 10.4324/9781003030737

Mann, D., and van Ginneken, P. (2017). Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J. Sports Sci.* 35, 784–790. doi: 10.1080/02640414.2016.1189588

Manson, S., Brughelli, M., and Harris, N. (2014). Physiological characteristics of international female soccer players. *J. Strength Condit. Res.* 28, 308–318. doi: 10.1519/JSC.0b013e31829b56b1

Mendez-Villanueva, A., Suarez-Arrones, L., Rodas, G., Fernandez-Gonzalo, R., Tesch, P., Linnehan, R., et al. (2016). MRI-based regional muscle use during hamstring strengthening exercises in elite soccer players. *PLoS ONE* 11:e0161356. doi: 10.1371/journal.pone.0161356

Murr, D., Larkin, P., and Höner, O. (2020). Decision-making skills of high-performance youth soccer players. *Ger. J. Exerc. Sport Res.* 51, 102–111. doi: 10.1007/s12662-020-00687-2

Murr, D., Raabe, J., and Höner, O. (2018). The prognostic value of physiological and physical characteristics in youth soccer: a systematic review. *Eur. J. Sport Sci.* 18, 62–74. doi: 10.1080/17461391.2017.1386719

Muthén, L., and Muthén, B. (2017). *Mplus User's Guide (Eighth Edition Edn.)*. Los Angeles, CA: Muthén and Muthén.

Neubauer, A., and Schmiedek, F. (2020). Studying within-person variation and within-person couplings in intensive longitudinal data: lessons learned and to be learned. *Gerontology* 66, 332–339. doi: 10.1159/000507993

Newell, K. (1986). "Constraints on the development of coordination," in *Motor Development in Children: Aspects of Coordination and Control,* eds M. Wade and H. Whiting (Dordrecht: Martinus Nijhoff), 341–360.

Nolan, J., and Howell, G. (2010). Hockey success and birth date: the relative age effect revisited. *Int. Rev. Sociol. Sport* 45, 507–512. doi: 10.1177/1012690210371560

Parr, J., Winwood, K., Hodson-Tole, E., Deconinck, F., Hill, J., Teunissen, J., et al. (2020). The main and interactive effects of biological maturity and relative age on physical performance in elite youth soccer players. *J. Sports Med.* 2020:1957636. doi: 10.1155/2020/1957636

Peña-González, I., Fernández-Fernández, J., Moya-Ramón, M., and Cervell,ó, E. (2018). Relative age effect, biological maturation, and coaches' efficacy expectations in young male soccer players. *Res. Q. Exerc. Sport* 89, 373–379. doi: 10.1080/02701367.2018.1486003

Roberts, S., McRobert, A., Rudd, J., Enright, K., and Reeves, M. (2020). Research in Another un-Examined (RAE) context. A chronology of 35 years of relative age effect research in soccer: is it time to move on? *Sci. Med. Football* 1–9. doi: 10.1080/24733938.2020.1841278

Romann, M., and Cobley, S. (2015). Relative age effects in athletic sprinting and corrective adjustments as a solution for their removal. *PLoS ONE* 10:e0122988. doi: 10.1371/journal.pone.0122988

Romann, M., Rössler, R., Marie, J., and Faude, O. (2018). Relative age effects in Swiss talent development – a nationwide analysis of all sports. *J. Sports Sci.* 36, 2025–2031. doi: 10.1080/02640414.2018.1432964

Romann, M., Rüeger, E., Hintermann, M., Kern, R., and Faude, O. (2020). Origins of relative age effects in youth football - a nationwide analysis. *Front. Sports Active Living* 2:591072. doi: 10.3389/fspor.2020.591072

Saward, C., Hulse, M., Morris, J., Goto, H., Sunderland, C., and Nevill, M. (2020). Longitudinal physical development of future professional male soccer players: implications for talent identification and development? *Front. Sports Act. Living* 2:578203. doi: 10.3389/fspor.2020.578203

Schroepf, B., and Lames, M. (2018). Career patterns in German football youth national teams – a longitudinal study. *Int. J. Sports Sci. Coaching* 13, 405–414. doi: 10.1177/1747954117729368

Sheppard, J., Dawes, J., Jeffreys, I., Spiteri, T., and Nimphius, S. (2014). Broadening the view of agility: A scientific review of the literature. *J. Austr. Strength Cond.* 22, 6–25.

Sieghartsleitner, R., Zuber, C., Zibung, M., and Conzelmann, A. (2019). Science or coaches' eye?–both! Beneficial collaboration of multidimensional measurements and coach assessments for efficient talent selection in elite youth football. *J. Sports Sci. Med.* 18, 32–43.

Suppiah, H., Low, C., and Chia, M. (2015). Detecting and developing youth athlete potential: different strokes for different folks are warranted. *Br. J. Sports Med.* 49, 878–882. doi: 10.1136/bjsports-2015-094648

Toering, T., Elferink-Gemser, M., Jordet, G., and Visscher, C. (2009). Self-regulation and performance level of elite and non-elite youth soccer players. *J. Sports Sci.* 27, 1509–1517. doi: 10.1080/02640410903369919

Towlson, C., MacMaster, C., Gonçalves, B., Sampaio, J., Toner, J., MacFarlane, N., et al. (2020). The effect of bio-banding on physical and psychological indicators of talent identification in academy soccer players. *Sci. Med. Football* 1–13. doi: 10.1080/24733938.2020.1862419

Unnithan, V., White, J., Georgiou, A., Iga, J., and Drust, B. (2012). Talent identification in youth soccer. *J. Sports Sci.* 30, 1719–1726. doi: 10.1080/02640414.2012.731515

Votteler, A., and Höner, O. (2014). The relative age effect in the German Football TID Programme: biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players. *Eur. J. Sport Sci.* 14, 433–442. doi: 10.1080/17461391.2013.837510

Votteler, A., and Höner, O. (2017). Cross-sectional and longitudinal analyses of the relative age effect in German youth football. *Ger. J. Exerc. Sport Res.* 47, 194–204. doi: 10.1007/s12662-017-0457-0

Wattie, N., Cobley, S., and Baker, J. (2008). Toward a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

Webdale, K., Baker, J., Schorer, J., and Wattie, N. (2020). Solving sport's 'relative age' problem: a systematic review of proposed solutions. *Int. Rev. Sport Exerc. Psychol.* 13, 187–204. doi: 10.1080/1750984X.2019.1675083

Williams, A., Ford, P., and Drust, B. (2020). Talent identification and development in soccer since the millennium. *J. Sports Sci.* 38, 1199–1210. doi: 10.1080/02640414.2020.1766647

Williams, A., and Reilly, T. (2000). Talent identification and development in soccer. *J. Sports Sci.* 18, 657–667. doi: 10.1080/02640410050120041

Wrang, C., Rossing, N., Lilholt, R., Hansen, C., Hansen, C., and Karbing, D. (2018). Relative age effect and the re-selection of danish male handball players for national teams. *J. Hum. Kinet.* 63, 33–41. doi: 10.2478/hukin-2018-0004

Yagüe, J. M., Molinero, O., Alba, J. Á., and Redondo, J. C. (2020). Evidence for the relative age effect in the spanish professional soccer league. *J. Hum. Kinet.* 73, 209–218. doi: 10.2478/hukin-2019-0145

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ORIGINAL RESEARCH
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Exploring Relative Age Effects in Youth Ice Hockey Through a Single Team Case Study and Composite Narratives

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Relative age effects (when birthdate influences participation or performance) in sport potentially influence the experiences of sport participants, including athletes, parents, and coaches. Nearly all existing literature on relative age effects adopts a quantitative approach, limiting our understanding of the phenomenon. Thus, the purpose of this unique study was to explore relative age effects using an instrumental, descriptive case study approach with one elite, youth, male ice hockey team. This context was chosen given the high prevalence of relative age effects among such groups. Participants included 20 athletes, 19 parents, and two coaches from one team. Data were collected through biometric measures, semistructured interviews, and participant observations. Results were presented as five composite narratives: relatively older athletes, relatively younger athletes, parents of relatively older athletes, parents of relatively younger athletes, and coaching staff. The narratives demonstrated unique relative age experiences for each group of participants. Discussion aligns the results with the social agents model that explains relative age effects. Practical recommendations for sport participants are also provided.

Keywords: birthdate, participation, qualitative analysis, case study design, relative age effects, youth sport

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INTRODUCTION

There are a number of factors that influence the acquisition of expertise in any field. In sport, Baker and Horton (2004) expressed the importance of considering primary and secondary influences on athletic expertise. Primary influences such as genetics and training directly affect expertise, whereas secondary influences such as sport maturity and depth of competition indirectly affect expertise. Despite the term, researchers generally describe secondary influences as equally important as primary ones and have spent considerable efforts understanding secondary influences that affect expert development. Baker and Horton outlined several factors that indirectly influence talent development including cultural importance of sport (e.g., Robinson, 1998), access to quality coaching (e.g., Côté and Gilbert, 2009), and familial support (e.g., Côté, 1999). Secondary influences extend to birth advantages, such as birthplace effects (Côté et al., 2006) and the focus of this study, relative age effects (Cobley et al., 2009).

"Relative age effects" occur when one's birthdate influences sport participation or performance (Musch and Grondin, 2001). This phenomenon is prevalent in youth sport, where children are frequently grouped into 1-year age cohorts. In most ice hockey organizations, for instance, children compete with peers born in the same calendar year (e.g., Barnsley and Thompson, 1988). Thus, a child born January 1 is 364 days older than a child born December 31, yet the two children compete in the same age division. Relatively older athletes are afforded participation (i.e., increased enrollment; Turnnidge et al., 2014) and performance advantages (i.e., increased representation on elite teams; Hancock et al., 2013b), while relatively younger athletes are more apt to drop out (Delorme et al., 2010). Relative age effects exist in several sports including ice hockey (e.g., Barnsley et al., 1985; Nolan and Howell, 2010), association football (e.g., Cobley et al., 2008; Figueiredo et al., 2019), rugby (e.g., Lemez et al., 2016; Cobley and Till, 2017), tennis (e.g., Ulbricht et al., 2015; Gerdin et al., 2018), skiing (e.g., Baker et al., 2014; Müller et al., 2015), basketball (e.g., Delorme et al., 2011; Arrieta et al., 2015), and gymnastics (e.g., Baker et al., 2014; Hancock et al., 2015). Furthermore, relative age effects exist in Australia (e.g., van den Honert, 2012), Brazil (e.g., Okazaki et al., 2011), Canada (e.g., Nolan and Howell, 2010), France (e.g., Delorme et al., 2011), Germany (e.g., Ulbricht et al., 2015), UK (e.g., Till et al., 2014), and the USA (e.g., Giacomini, 1999), to name a few.

Relative age effects facilitate sport inequities that are driven by arbitrary dates[1]. These inequities potentially lead to long-term consequences that ought to be concerning to sport organizations and governments. Specifically, one possible consequence is a reduced talent pool at older age categories, as relatively younger athletes are more likely to discontinue sport before attaining their potential. Relative age effects ought to be concerning as well from the athlete's perspective. A possible consequence of a system that advantages relatively older athletes is health concerns, as relatively younger athletes miss out on important physical activity and social opportunities when they drop out of sport. For both reasons, it is imperative to gain a deeper understanding of relative age effects.

Recently, researchers began conceptualizing models to explain relative age effects. The model most relevant to this study is the social agents model by Hancock et al. (2013a). The authors described relative age effects as a social phenomenon, heavily influenced by parents', coaches', and athletes' actions and perceptions. Hancock et al. (2013a) proposed that parents register relatively older children in sport at younger ages, and these initial advantages lead to further advantages known as a Matthew effect (Merton, 1968). This initial enrollment bias affords relatively older children more sport experience, training, instruction, and skill development than their relatively younger counterparts, leading to potential performance advantages in subsequent years. The authors also suggested that parents have higher sport expectations for their relatively older children, leading to a Pygmalion effect (Rosenthal and Jacobson, 1968). For instance, a parent's heightened expectation for athletic success could potentially transform behavior whereby they register their child for additional sport clinics. In turn, this leads to a behavioral change within their child, whereby they believe they are talented and commit to additional practice time. In such scenarios, athletes confirm their parents' expectations, completing a self-fulfilling prophecy. According to the model (Hancock et al., 2013a), coaches are provided with a relatively older talent pool due to the initial enrollment bias. The authors also hypothesized that, similar to parents, coaches form high expectations of relatively older athletes, spurring another self-fulfilling prophecy or Pygmalion effect (Rosenthal and Jacobson, 1968). An example is coaches providing more instruction to relatively older athletes, who improve their skills beyond that of relatively younger athletes. Finally, based on parents' and coaches' expectations, athletes might then form new self-expectations regarding their ability and relative age, known as a Galatea effect (Merton, 1948), which influences relative age effects.

The model by Hancock et al. (2013a) places social agents at the root of relative age effects. Essentially, if parents and coaches had equal expectations and perceptions for relatively older and younger athletes, then relative age effects would dissipate, if not disappear. The goal of this paper is not to debate if this is true; however, the authors' claims are substantiated in that social agents clearly influence relative age effects. This warrants further investigation into social agents and relative age effects.

With few exceptions (Chittle, 2020; Lidor et al., 2021), the research on relative age effects has been acquired through quantitative approaches, often relying on archival methods. It is vital that researchers interact directly with social agents to understand relative age effects. Thus, the purpose of the present study was to use a case study approach to investigate how athletes, parents, and coaches experience relative age effects. This includes their awareness of the effect, its existence within the team, and their perceptions of the effect on athletic development. The study design immersed the researcher in one ice hockey team's culture, providing a deeper understanding of the influence of relative age effects on the team.

MATERIALS AND METHODS

The procedures described herein were approved by the author's Institutional Review Board. All participants provided informed consent/assent prior to participation.

Researcher Paradigm

The researcher aligns with the pragmatic paradigm (Dewey, 1931; Morgan, 2014), whereby he is not concerned with debates of truth and reality, since such debates cannot be conclusively ruled upon (Giacobbi et al., 2005). The pragmatic paradigm is effective in eliciting an understanding of "real-world" problems and focuses on finding meaning that is useful to the studied population (James, 1907; Rorty, 1990; Maxcy, 2003). Given that relative age effects have a tangible influence on youth sport participants' experiences, it seemed appropriate to adopt the pragmatic paradigm. Guided by this paradigm, all methodological decisions were based on increasing the relevance of this research to youth sport participants (e.g., athletes, parents, and coaches). This was the impetus for a case study design. Rather than sample a number of sports or teams, the researcher studied one team to capture participants' experiences with relative age effects and provide a

[1]Changing selection dates is ineffective, as advantages shift along with the selection dates (see Helsen et al., 2000).

depth of understanding that is lacking when athletes are studied using large, cross-sectional, quantitative designs.

Case Study Design

The study purpose led the researcher to conclude that a case study design would be best suited to (1) uncover meaningful results by including multiple sport participants (i.e., athletes, parents, and coaches) and (2) frame the results to be useful and tangible for the ice hockey community. Specifically, the researcher employed an instrumental (using one case to understand other cases; Stake, 1995), descriptive (describing a phenomenon in its real-world context; Yin, 2014) case study approach with one ice hockey team to understand participants' experiences related to relative age effects in the youth sport environment.

Participants

The strongest relative age effects are typically found in male, physically demanding, team-oriented, competitive, and regionally popular sports—especially when athletes are in or nearing puberty (Cobley et al., 2009; Hancock, 2020). The chosen team, therefore, was a North American, "AAA" (highest competitive level for youth), male ice hockey team. Athletes were 14 or 15 years old but born during the same calendar year (i.e., some had their 15th birthday before the season ended). The sample included all 20 athletes, 19 parents, one head coach, and one assistant coach.

Data Collection

To build a strong case study, data collection ought to arise from multiple sources (Yin, 2014). Herein, data collection included three sources as per Yin's (2014) categorization of case study evidence: direct observations, semistructured interviews, and participant observations.

Direct Observations

The researcher selected three measures for direct observations. First, athletes self-reported their birthdates. North-American ice hockey establishes age divisions based on the calendar year, with the relatively oldest athletes born in January. Athletes were considered relatively older if they were born between January 1 and June 30, while relatively younger athletes were born from July 1 to December 31. This yielded 13 relatively older athletes and seven relatively younger athletes. As the parents of one athlete did not consent to participate, there were 12 parents of relatively older athletes and seven parents of relatively younger athletes.

Second, relative age effects are often—and perhaps falsely—attributed to the physical differences that exist between athletes of differing ages (Hancock, 2020). It was important, therefore, to collect athletes' basic biometric measures to provide context regarding how athletes of differing relative age might experience physical differences. The researcher measured height, weight, and strength, since sport scientists often cite these as advantageous for relatively older athletes (Till et al., 2014). For height, a tape measure was secured to a wall and athletes were measured without wearing shoes or hats. Athletes were weighed on an electronic scale while wearing only their moisture-wicking base layer that is traditionally worn under ice hockey equipment. Next, athletes performed a grip-strength test, following the procedures outlined by the American College of Sports Medicine (2009).

For the third direct observation, participants estimated biometric rankings, providing insights into their awareness and perceptions of the relationship between relative age and growth. Athletes ranked themselves compared with their teammates for age, height, weight, and grip strength. As an example, athletes were asked, "With #1 being tallest and #20 being shortest, where do you rank your height compared to your teammates?" Similarly, parents ranked their child compared with his teammates for each biometric measure. The head coach and assistant coach rank ordered every athlete on each of the biometric measures.

Semistructured Interviews

The researcher began by using a random number generator to select 10 athletes (which yielded six relatively older and four relatively younger athletes) to engage semistructured interviews. The social agents model (Hancock et al., 2013a) that guided this research suggests parents' behaviors influence athletes' expectations. Thus, to see if similarities existed between parents' and athletes' responses, the parents of the 10 interviewed athletes also engaged in semistructured interviews. Parents could interview together ($n = 2$) or have one person represent the parent unit ($n = 8$). When two parents were interviewed together, they were treated as one participant. Lastly, the head coach was interviewed after the athlete and parent interviews. Upon completing these interviews, it was evident that data saturation was reached; thus, no further interviews were conducted.

Interview questions were guided by the study purpose and aligned with the instrumental, descriptive case study design (i.e., understanding the relative age effect through the lens of one youth ice hockey team). Questions were shaped by a pragmatic paradigm, with the goal of discovering information that was useful to youth ice hockey participants. Interviews began by identifying participants' knowledge of relative age effects (e.g., What, if anything, can you tell me about relative age effects?). Next, participants were asked about perceptions of relative age effects (e.g., Do you have any guesses as to why relatively older athletes are selected to elite teams?). Third, participants were asked about the link between relative age and size/ability (e.g., Do you think birthdate can influence someone's chances of being a good ice hockey player?). Finally, participants were asked personally relevant questions (e.g., If given the chance, would you change your [son's] birthdate?). The coach was asked if he made team selection decisions based on birthdate, height, weight, and/or strength. Probes were placed in the interview guide to elicit more information from participants. After developing the initial interview guide, the researcher conducted a pilot interview with a colleague who was well-versed in qualitative methods and relative age effects. Based on his feedback, the researcher made minor changes to question wording. Interviews took place after the season in the participants' homes, with athletes interviewed before their parents. The researcher did not provide participants with any information about relative age effects before the semistructured interviews. The average and anticipated interview lengths were as follows: athletes (10:51 min;

15 min), parents (18:24 min; 20 min), and head coach (32:09 min; 30 min). Interviews were transcribed verbatim by the researcher for later data analysis.

Participant Observations

According to Yin (2014), participant observations involve the researcher actively engaging with the participants, rather than being a passive observer. In this study, the researcher interacted with the participants on several occasions for the purposes of recruitment, informed consent/assent, and collecting biometric measures. These interactions spanned several weeks whereby the researcher attended six practices and two games (a total of 20 h). It was not necessary for the researcher to remain at the practices and games for their entire duration, but in doing so, he was able to develop rapport with participants, observe their behaviors, and engage in conversations with participants (primarily parents, but also athletes and coaches to a lesser extent). After each practice/game, the researcher made field notes about his observations that helped to inform probing questions during the interviews, interpret the interviews, and provide context to the composite narratives.

Data Analysis: Composite Narratives

Composite narratives (Willis, 2019) allow researchers to reflect on participant data and communicate a story to the reader that captures participants' emotional truth (Orbach, 2000; Wertz et al., 2011). Several factors led the researcher to choose composite narratives. First, conducting inferential analyses did not align with the case study design—especially given that quantitative measures were taken from only 20 athletes. Second, throughout data collection, it was evident that each participant group (i.e., athletes, parents, and coaches) had unique experiences with relative age effects. Third, composite narratives offer non-academic audiences a better understanding of phenomenon than traditional qualitative methods that employ codes and themes to communicate findings (Willis, 2019), which is a crucial tenet of the researcher's pragmatic paradigm. All sources of data collection were synthesized into five composite narratives representing (1) relatively older athletes, (2) relatively younger athletes, (3) parents of relatively older athletes, (4) parents of relatively younger athletes, and (5) the coaching staff.

Quality composite narratives must be created transparently (Willis, 2019). Herein, the researcher incorporated five main principles. First, the researcher played competitive ice hockey for 13 years, has refereed competitive ice hockey for 23 years, and has studied relative age effects for 13 years. This led participants to treat him as an "insider" with excellent ice hockey acumen. Second, multiple sources of information informed the composite narratives. Whereas, the interviews accounted for most of the content, each athlete narrative (i.e., relatively older and younger) included the group's average birthdate, height, weight, and strength. Additionally, participants' estimated rankings and participant observations provided context to the narratives that helped understand how relative age influenced the respective groups. Third, presentation of the narratives was carefully chosen. Each narrative was assigned a pseudonym. Though differing opinions exist (e.g., Wertz et al., 2011; Willis, 2019), the composite narratives were written in third person to highlight the participant-researcher interactions. Any direct quotes in the composite narratives were gleaned from the interviews verbatim. Fourth, choices regarding the content to include in the composite narratives were important. The researcher relied on his background and experiences in ice hockey and relative age effects to select content he deemed most relevant (i.e., directly or tangentially related to relative age effects) to the respective composite narratives. Fifth, the composite narratives represent the researcher's interpretation of participants' data. After presenting the composite narratives, the researcher then unpacked their meaning in the discussion.

Methodological Quality and Rigor

The researcher enacted three techniques to enhance quality and rigor. First, the study maintained methodological coherence (Mayan, 2009), as the decisions in the study (e.g., purpose, case study design, composite narratives, and discussion) all aligned with the researcher's pragmatic paradigm. Second, to ensure a rich description (Creswell, 1998) in the composite narratives, the researcher had extended contact with the participants over the span of six weeks, which included attending six practices and two games (a total of 20 h). Third, Yin (2014) outlined three criteria to assess the quality of descriptive case study designs: construct validity, external validity, and reliability. Construct validity refers to providing operational definitions related to the research topic and design (Yin, 2014). The researcher established construct validity by clearly defining relative age effects and past findings in the literature review, including multiple sources of data collection, and ensuring participants understood relative age effects during the interviews. External validity entails developing a research question that addresses how something happens (Yin, 2014). For external validity, the data collection was directed by a "how" research question, namely, "How do athletes, parents, and coaches experience relative age effects?" External validity was further enhanced by the inclusion of the social agents model (Hancock et al., 2013a). Thus, there is potential for the results herein to be generalized to similar sport contexts where relative age effects might be influenced by social agents. Reliability relates to the ability of other researchers to follow the same procedures and reproduce similar results (Yin, 2014). Through precise description of the case study methods and composite narrative decisions, the study attained reliability.

RESULTS

Derek (Relatively Older Athlete)

Born March 22, Derek is among the older athletes on the team, having already turned 15 years old before the season ends. He has played ice hockey for 10 years and now plays defense. Derek seems excited about the biometric measurements. Derek stands 173 cm tall (9th tallest), weighs 68 kg (9th heaviest), and has a grip strength score of 37 kg (10th strongest). Compared with his teammates, Derek predicts he is 9th tallest, 8th heaviest, and 8th strongest. Before the study, Derek had never heard of relative age effects, but now explains the effect as, "It has something to do with your birthday." Derek thinks being relatively older leads to physical advantages, "They tend to grow up faster. They tend to get bigger before everybody else. So it gives them a performance edge, I suppose." However, he indicates that relative age is not the sole factor for performance, "I just think it all depends on how bad you want it, how hard you work, you know? I don't think [your age] really matters." When asked if athletes are selected to teams simply because of size, Derek equivocates, stating it is easier for bigger athletes to get noticed, but stops short of saying it is a conscious process. Probed about whether a poor-skating, 200-cm-tall athlete would get selected to a team, he relents, "Yeah, because you can improve skating." Oppositely, Derek recounts a situation where a smaller athlete got deselected because of his size, "He didn't get chosen…and he was better than [the athlete who was selected]; he didn't make it just 'cause he was, like, half the size." Though Derek believes one's birthdate might influence chances of becoming a good ice hockey player ("Yeah, probably, because they may get introduced to the sport earlier and they may develop their skills earlier on, so they're better at it."), he emphatically disagrees that his birthdate influences his height, weight, or strength and is not certain it has influenced his chances of becoming a good ice hockey player.

Colin (Relatively Younger Athlete)

Born September 24, Colin is relatively younger compared with his teammates and will not turn 15 years old until next season. He plays offense, accumulating 7 years of ice hockey experience, though several years were in non-competitive divisions. Colin is noticeably shorter and lighter than Derek, and he is unenthusiastic about the biometric measures. The measures confirm his biometric disadvantages. Colin stands 167 cm tall (13th tallest), weighs 59 kg (13th heaviest), and scores 34 kg (12th strongest) on the grip strength test. Colin holds a favorable perception of his biometrics, estimating he is 12th tallest, 11th heaviest, and 10th strongest on the team. He had never heard of relative age effects before the study but now has a better grasp of the effect, "It is like if you are born between certain months, you're supposed to be better at hockey or better at sports." When probed, Colin homes in on opportunities such as entry age, experience, and practice to explain why relatively older athletes have advantages, "Maybe just because they're a little bit older, so they'd have more time practicing." Colin has witnessed situations where athletes were selected to teams simply because of their size, "Quite often, because [coaches] just see a big kid and just love them. I didn't like that very much…[be]cause obviously I'd choose the person that's better—not because of their height or weight, but because they're better." Similarly, he experienced situations where athletes were deselected from teams based on size, "One of my friends got cut from a team. The coach told him he was too small to be on the team…he wasn't on the team because he was too small." Colin appeared receptive to the idea that birthdate might influence chances of becoming a good ice hockey player (e.g., "I think it could, but at the same time it might depend on their work ethic too.") but disagreed that his birthdate influenced his height, weight, strength, or chances of becoming a good ice hockey player.

Lesley (Parent of Relatively Older Athlete)

Lesley is Derek's mother, who is one of the oldest athletes on the team. She has not heard of the relative age effect before beginning the study but seems curious about how it might have influenced Derek. Lesley holds a favorable view of Derek's biometrics, predicting he is 8th tallest, 8th heaviest, and 7th strongest (he was 9th, 9th, and 10th, respectively). Since the study began, Lesley has spoken with other team parents about relative age effects and realizes that birthdate might influence ice hockey success, "I've wondered if some of those kids that are at the end of the birth year, if they tend not to go as far because they are smaller." As Lesley discusses her son, it is evident she sees a link between birthdate and physical prowess, "The older [athletes] should be typically the larger or the stronger or grow faster—you know, they're more mature. They're ahead of the others with the time they've had, right?" Despite this, Lesley indicates athletes were rarely chosen to elite teams because of their size, and further states that Derek's size is more a genetic factor than related to his birthdate, "I don't see how the birthdate really—I mean he's going to grow at the speed of his genetics… I don't think it matters what month you're born when you're going to hit puberty." Lesley shares Derek's belief that birthdate could influence success in ice hockey ("The January, February, March birthdays probably being the better hockey players or having the chance to be the better hockey players—because of being older, being more mature, hitting the maturity quicker than the younger kids. I don't know if that's 100% true, but I would say that it's a probability that there's more with earlier birthdates in the year.") but does not believe this has been the case for Derek. Lastly, Lesley states that Derek's birthdate never influenced sport enrollment decisions, "No, never."

Andrew (Parent of Relatively Younger Athlete)

Andrew is Colin's father, who is one of the youngest athletes on the team. He has heard of relative age effects and is intrigued about what the study might reveal. Andrew overestimates Colin's biometrics, predicting he is 11th tallest, 12th heaviest, and 8th strongest (he was 13th, 13th, and 12th, respectively). Andrew heard about relative age effects from the book *Outliers*, as well as a conversation with his daughter's soccer coach. He says his son's later birthdate piqued his interest in relative age effects. Asked why relatively older athletes have sport advantages, Andrew focuses on physical differences at young ages, "There's a significant difference between a 10-year-old born in January than a 9-year-old born in December. And so it may be early on because of those differences, those kids get frustrated or whatever and find something else to do." Continuing, Andrew highlights that relatively older athletes likely draw coaches' attention at tryouts because of their size and that many coaches select athletes based on physical characteristics rather than skill, "I do truly believe—particularly at this age and even last year or maybe the year before that—I think coaches specifically chose kids based on their size at a tryout." When speaking of birthdate and size, Andrew says, "It's probably more genetics than anything else. I was the same as [Colin]—birthdate doesn't make a big deal." Andrew is uncertain if there is a link between birthdate and success in ice hockey, "I mean, it might. I just think there's so many other determining factors…it might be one factor out of 10 or 15 other ones. But I wouldn't put it at the top. There's a lot of other factors that I would put ahead of birth[date]." Referring to Colin's birthdate influencing his chances at being a good ice hockey player, Andrew states "I don't know, but I don't think [coaches are] looking at the birthdates. To the best of my ability I think they're more looking at the height, weight over birthdate." Lastly, Andrew has never made sport enrollment decisions based on Colin's birthdate.

Paul (Coaching Staff)

Paul enthusiastically agrees for his team to be in the study, saying he is aware of relative age effects and would like to contribute to the growing body of knowledge. Paul finds the estimated rankings challenging since he does not focus on biometrics. Examining absolute differences between actual and estimated rankings (e.g., if the 10th tallest athlete was estimated as 8th or 12th tallest, the difference was "2"), Paul is more accurate with visible metrics (height = 1.1 average difference; weight = 3.5) than non-visible metrics (age = 4.8; strength = 6.4). In the interview, it is evident that Paul knows more about relative age effects than any of the athletes or parents in the study. He thoroughly describes the effect, including the futility of changing selection dates (aligned with Helsen et al., 2000). Paul explains relatively older athletes' sport advantages, "11 months is a long time when you're a 5- or 6- or 7-year-old. The competitive advantages that would go with being born in January of a year vs. December and those kids competing against each other would be the same as a baby learning to crawl at a certain time vs. a baby that's born later and comparing those two babies in terms of their motor development." Whereas Paul does not select athletes solely due to their size, he concedes it influences selection decisions when comparing similarly skilled athletes, "If I have two athletes of equal talent, I'll go with the bigger athlete. They are more durable, typically. They bring a physical component beyond the skill set. If they're bigger, they command more respect on the ice." Paul also believes relatively older athletes have better odds of excelling in ice hockey due to their size, "So you see him out there and now he's got 5 inches or 6 inches on some of these kids and probably 35, 40 pounds on some of them. So yeah, I think it does [increase success] because even if he's not the most talented kid out there, he makes room for himself just from other kids getting out of the way." Ultimately, Paul considers size and strength during team selections and acknowledges these characteristics are likely related to relative age.

DISCUSSION

The researcher used an instrumental, descriptive case study design with one elite, male, youth ice hockey team to understand participants' experiences with relative age effects. Five composite narratives with multiple sources of data represented relatively older athletes, relatively younger athletes, parents of relatively older athletes, parents of relatively younger athletes, and the coaching staff. Since the interpretation of the composite narratives aligns with the social agents model for relative age effects, this section follows the same order Hancock et al. (2013a) outlined in their article (i.e., parents, coaches, and athletes).

Parents

Lesley (parent of a relatively older athlete) and Andrew (parent of a relatively younger athlete) shared some similar relative age experiences. For instance, both parents acknowledged relatively older athletes might have size advantages over relatively younger athletes. Lesley and Andrew believed this could manifest into ice hockey success through better skills, but more so, they believed increased size could result in being selected to more elite teams, resulting in experiential and practice advantages. Despite these statements, both parents stated their child's growth was primarily driven by genetics and not birthdate. In this sense, they did not believe their child's size (dis)advantages were due to relative age.

Andrew also expressed some experiences that were markedly different than Lesley. Specifically, Andrew believed that team selection decisions were often based on size and not skill. It is not surprising that Andrew reported this experience, given that his son was noticeably smaller than other players and team selection decisions potentially negatively influence his son. In other words, Andrew is more cognizant of size disadvantages due to their potential negative consequences—this contrasts Lesley's experience, who would have no reason to be preoccupied with size during team selection decisions. Since Andrew's son overcame his size disadvantage to be selected to an elite team, it might explain his more favorable biometric rankings, as he views his son has proven himself to be similar to other players on the team.

The results do not support that parents hold different perceptions of relatively older and younger athletes that would explain Matthew effects (Merton, 1968). It is important to note, however, that parents were interviewed 10 years after they could have registered their children for ice hockey, perhaps preventing accurate recall of those decisions. Secondly, this study did not include parents of athletes who played in non-competitive ice hockey or parents of athletes who dropped out of ice hockey—their enrollment decisions might be very different than Lesley's and Andrew's. For Pygmalion effects (Rosenthal and Jacobson, 1968), both parents have expectations and perceptions regarding relative age effects that have the potential to influence their sons. Lesley perceives ice hockey success to be about growth and maturation, Derek's advanced size is related to genetics, and team selections are rarely based on size. These perceptions might lead Derek to feel more secure about his odds of becoming a good ice hockey player as these factors are advantageous for him. Meanwhile, Andrew perceives ice hockey success to be about many factors, Colin is small because of genetics, and team selections are frequently based on size. This could lead Colin to believe he has too many negative factors to overcome as he pursues ice hockey success, potentially leading to drop out. The researcher believes both parents' perceptions of (dis)advantages are based on relative age (even if the parents did not use the term) and demonstrate potential Pygmalion effects (Rosenthal and Jacobson, 1968).

Coaching Staff

Paul had significant knowledge about relative age effects. He explained the effects in terms of development, maturity, and experiential advantages, leading him to conclude that shifting selection dates would simply shift who is advantaged by the system. Paul claimed he did not focus on his players' relative age, height, weight, and strength, which was supported by how challenging he found the estimated biometric rankings. However, he also stated that if he had to choose between two similarly skilled athletes for his team, he would choose the bigger player with the assumption that player is more durable and creates more space on the ice.

Paul's insights very much align with the social agents model (Hancock et al., 2013a). First, his description of an 11-month age difference at young ages is nearly identical to Hancock et al. (2013a) explanation of how Matthew effects (Merton, 1968) benefit relatively older children (i.e., early age advantages lead to more experience, practice, instruction, and, therefore, team selections). Second, when faced with choosing one athlete out of two similarly skilled athletes, Paul selects the bigger player because he perceives many positive benefits from this athlete (e.g., durability, ability to create space, can intimidate opponents, etc.). This is, in fact, the beginning of the Pygmalion effect (Rosenthal and Jacobson, 1968), which is potentially grounded in false beliefs. To the researcher's knowledge, there is no relationship between a youth athlete's size and their durability, fearlessness/courage, or ability to intimidate opponents. Nevertheless, Paul holds this belief to be true, which influences his team selection decisions. This likely benefits relatively older athletes who get more practice, playing time, and instruction, thereby leading to performance improvements and completing Paul's self-fulfilling prophecy (Merton, 1948).

Athletes

The athlete interviews were shorter than expected, as many interviewees provided quick responses even after probing from the researcher. Nevertheless, as a collective group, their responses provide interesting insights into relative age effects. Derek's relative age experiences exemplified a stereotypical relatively older athlete. He was taller, heavier, and stronger than Colin and held a favorable perception of his biometric rankings. He entered the study without having heard about relative age effects and ended the study with little improvement of that knowledge. Initially resistant to the idea that size was a determining factor in team selection decisions, Derek eventually conceded that it is a factor for athletes at the extreme ends of the spectrum—though he was clear to point out that birthdate and size had not influenced his success in ice hockey. Reflecting on Derek's experiences, his approach mirrored that of someone with privilege in that he did not see a connection between his relative age and size, did not care to learn much about relative age effects, and did not think size was much of an advantage in ice hockey until the researcher probed more on the issue.

Oppositely, Colin experienced what would be expected of a relatively younger athlete. He was shorter, lighter, and weaker than Derek but ranked his biometrics better than reality. By the end of the study, Colin demonstrated superior relative age effects knowledge, possibly because it held stronger meaning for him. Colin's father indicated he became interested in relative age effects given his son's later birthdate—perhaps Colin's curiosity was sparked in the same way. Additionally, Colin was convinced that size is an instrumental factor in team selections and provided several examples of this. Again, his experiences of being relatively younger and smaller might have contributed to stronger perceptions of size and team selection decisions. Despite these experiences, Colin did not believe that his birthdate or size influenced his ability to succeed in ice hockey. While it is encouraging that Colin's experiences did not negatively affect his view on ice hockey success, it is important to acknowledge that his experiences are that of an athlete who was selected to the most elite ice hockey team in his region, which might differ greatly from an athlete who was deselected from the same team or who played non-competitive ice hockey.

According to the social agents model (Hancock et al., 2013a), Galatea effects (Merton, 1948) occur when external expectations and perceptions are placed on athletes, thereby influencing their expectations, perceptions, and behaviors. In this case study, it appears that Derek's and Colin's experiences and perceptions of relative age effects align with their parents. Derek and his mother both shared the belief that birthdate and size might influence ice hockey success but did not believe it was a significant factor nor that it was the case for Derek. Colin and his father, on the other hand, were both more mindful of relative age effects. They expressed more relative age effects knowledge, stated birthdate could contribute to ice hockey success, and believed size was important to team selection decisions (though again, did not believe Colin's odds for future success would be predicated on relative age). It would seem, then, that Derek and Colin have formed perceptions about relative age effects that align with external expectations and perceptions from their parents—a Galatea Effect (Merton, 1948).

Sport Participants

A main tenet of the pragmatic paradigm is ensuring the data are useful for the studied population. The following list provides six evidence-based recommendations taken from this study that are useful for sport participants.

1. Sport governing bodies should provide coaches with information on relative age effects and guidance on how to avoid relative age biases during team selections (i.e., setting objective selection criteria before tryouts to direct coaches' attention to athletes' skills rather than size).
2. Coaches ought to critically reflect on how relative age effects, or related factors such as size, might influence their team selection decisions.
3. Parents and coaches should learn more about relative age effects including the importance of having high expectations of all athletes regardless of relative age (i.e., expect all athletes to reach their potential and, for youth, do not place limits on what their potential could be).
4. Coaches can ensure that athletes understand what controllable factors led to them to being selected to, or deselected from, the team.

5. Sport governing bodies could provide athletes and parents with information to help them understand talent development and primary/secondary influences on expertise.
6. Sport scientists should work with sport governing bodies to explore why relatively younger athletes have lower initial enrollment rates.

Conclusion

This research contributes to the existing literature by demonstrating different relative age experiences for relatively older athletes, relatively younger athletes, parents of relatively older athletes, parents of relatively younger athletes, and coaches, all of whom were involved with one elite, youth, male ice hockey team. This is an important realization in relative age effects research and highlights the experiences of individual athletes, as opposed to identifying large cohort trends. Though the unique case study design has limitations (e.g., small sample size and challenges with generalizability beyond the studied context), it is evident that qualitative designs are beneficial to understanding relative age effects. Future researchers ought to consider more theory-based studies on relative age effects, such as exploring parents' roles in Matthew effects (Merton, 1968), investigating Pygmalion effects (Rosenthal and Jacobson, 1968) after team selections, and understanding how parents' and coaches' perceptions might initiate Galatea effects (Merton, 1948). Ultimately, such research will broaden our understanding of relative age effects in sport.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board; Indiana University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

DH completed all phases of the research.

REFERENCES

American College of Sports Medicine (2009). *Health-Related Physical Fitness Assessment Manual, 4th Edn*. Philadelphia, PA: Lippincott Williams and Wilkins.

Arrieta, H., Torres-Unda, J., Gil, S. M., and Irazusta, J. (2015). Relative age effect and performance in the U16, U18 and U20 European Basketball Championships. *J. Sports Sci.* 34, 1530–1534. doi: 10.1080/02640414.2015.1122204

Baker, J., and Horton, S. (2004). A review of primary and secondary influences on sport expertise. *High Abil. Stud.* 15, 211–228. doi: 10.1080/1359813042000314781

Baker, J., Janning, C., Wong, H., Cobley, S., and Schorer, J. (2014). Variations in relative age effects in individual sports: skiing, figure skating, and gymnastics. *Eur. J. Sport Sci.* 14(Suppl. 1), S183–S190. doi: 10.1080/17461391.2012.671369

Barnsley, R. H., and Thompson, A. H. (1988). Birthdate and success in minor hockey: the key to the NHL. *Can. J. Behav. Sci.* 20, 167–176. doi: 10.1037/h0079927

Barnsley, R. H., Thompson, A. H., and Barnsley, P. E. (1985). Hockey success and birthdate: the relative age effect. *Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Chittle, L. (2020). *The influence of relative age on developmental outcomes in female ice hockey (Unpublished doctoral dissertation)*. University of Windsor, Windsor, ON, Canada.

Cobley, S., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S. P., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cobley, S. P., and Till, K. (2017). Participation trends according to relative age across youth UK Rugby League. *Int. J. Sports Sci. Coach.* 12, 339–343. doi: 10.1177/1747954117710506

Côté, J. (1999). The influence of the family in the development of talent in sport. *Sport Psychol.* 13, 395–417. doi: 10.1123/tsp.13.4.395

Côté, J., and Gilbert, W. (2009). An integrative definition of coaching effectiveness and expertise. *Int. J. Sports Sci. Coach.* 4, 307–323. doi: 10.1260/174795409789623892

Côté, J., MacDonald, D. J., Baker, J., and Abernethy, B. (2006). When "where" is more important than "when": birthplace and birthdate effects on the achievement of sporting expertise. *J. Sports Sci.* 24, 1065–1073. doi: 10.1080/02640410500432490

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design. Choosing Among Five Traditions*. Thousand Oaks, CA: Sage.

Delorme, N., Boiché, J., and Raspaud, M. (2010). Relative age and dropout in French male soccer. *J. Sports Sci.* 28, 717–722. doi: 10.1080/02640411003663276

Delorme, N., Chalabaev, A., and Raspaud, M. (2011). Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand. J. Med. Sci. Sports* 21, 120–128. doi: 10.1111/j.1600-0838.2009.01060.x

Dewey, J. (1931). "The development of pragmatism," in *Pragmatism: The Classic Writings*, ed H. S. Thayer (London: Hackett), 23–40.

Figueiredo, A. J., Coelho-e-Silva, M. J., Cumming, S. P., and Malina, R. M. (2019). Relative age effect: characteristics of youth soccer players by birth quarter and subsequent playing status. *J. Sports Sci.* 37, 677–684. doi: 10.1080/02640414.2018.1522703

Gerdin, G., Hedberg, M., and Hageskog, C.-A. (2018). Relative age effect in Swedish male and female tennis players born in 1998-2001. *Sports* 6:38. doi: 10.3390/sports6020038

Giacobbi, Jr, P. R., Poczwardowski, A., and Hager, P. (2005). A pragmatic research philosophy for sport and exercise psychology. *Sport Psychol.* 19, 18–31. doi: 10.1123/tsp.19.1.18

Giacomini, C. P. (1999). Association of birthdate with success of nationally ranked junior tennis players in the United States. *Percept. Mot. Skills* 89, 381–386. doi: 10.2466/pms.1999.89.2.381

Hancock, D. J. (2020). "Antecedents and explanations of relative age effects," in *Relative Age Effects in Sport: International Perspectives*, eds J. C. Dixon, S. Horton, L. Chittle, and J. Baker (London: Routledge), 23–32.

Hancock, D. J., Adler, A. L., and Côté, J. (2013a). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Hancock, D. J., Ste-Marie, D. M., and Starkes, J. L. (2015). The relative age effect in female gymnastics: a flip-flop phenomenon. *Int. J. Sport Psychol.* 46, 714–725. doi: 10.7352/IJSP.2015.46.714

Hancock, D. J., Ste-Marie, D. M., and Young, B. W. (2013b). Coach selections and the relative age effect in male youth ice hockey. *Res. Q. Exerc. Sport* 84, 126–130. doi: 10.1080/02701367.2013.762325

Helsen, W. F., Starkes, J. L., and van Winckel, J. (2000). Effect of a change in selection year on success in male soccer players. *Am. J. Hum. Biol.* 12, 729–735. doi: 10.1002/1520-6300(200011/12)12:6<729::AID-AJHB2>3.0.CO;2-7

James, W. (1907). *Pragmatism: A New Name for Some Old Ways of Thinking*. London: Longmans, Green and Company.

Lemez, S., MacMahon, C., and Weir, P. (2016). Relative age effects in women's Rugby Union from developmental leagues to World Cup tournaments. *Res. Q. Exerc. Sport* 87, 59–67. doi: 10.1080/02701367.2015.1116120

Lidor, R., Maayan, Z., and Arnon, M. (2021). Relative age effect in 14- to 18 year-old athletes and their initial approach to this effect—Has anything changed over the past 10 years? *Front. Sports Act. Living* 3:622120. doi: 10.3389/fspor.2021.622120

Maxcy, S. J. (2003). "Pragmatic threads in mixed methods research in the social sciences: the search for multiple modes of inquiry and the end of the philosophy of formalism," in *Handbook of Mixed Methods in Social and Behavioral Research*, eds A. Tashakkori and C. Teddlie (Thousand Oaks, CA: Sage), 51–89.

Mayan, M. J. (2009). *Essentials of Qualitative Inquiry*. Walnut Creek, CA: Left Coast Press.

Merton, R. K. (1948). The self-fulfilling prophecy. *Antioch Rev.* 8, 193–210. doi: 10.2307/4609267

Merton, R. K. (1968). The Matthew effect in science. *Science* 159, 56–63. doi: 10.1126/science.159.3810.56

Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qual. Inq.* 20, 1045–1053. doi: 10.1177/1077800413513733

Müller, L., Hildebrandt, C., and Raschner, C. (2015). The relative age effect and the influence on performance in youth alpine ski racing. *J. Sports Sci. Med.* 14, 16–22.

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Nolan, J. E., and Howell, G. (2010). Hockey success and birth date: the relative age effect revisited. *Int. Rev. Sociol. Sport* 45, 507–512. doi: 10.1177/1012690210371560

Okazaki, F. H. A., Keller, B., Fontana, F. E., and Gallagher, J. D. (2011). The relative age effect among female Brazilian youth volleyball players. *Res. Q. Exerc. Sport* 82, 135–139. doi: 10.1080/02701367.2011.10599730

Orbach, S. (2000). *The Impossibility of Sex.* London: Penguin.

Robinson, L. (1998). *Crossing the Line: Violence and Sexual Assault in Canada's National Sport*. Toronto, ON: McClelland and Stewart Inc.

Rorty, R. (1990). "*Introduction: Pragmatism as anti-representationalism*," in *Pragmatism: From Peirce to Davidson*, ed J. P. Murphy (Boulder, CO: Westview Press), 1–6.

Rosenthal, R., and Jacobson, L. (1968). *Pygmalion in the Classroom*. New York, NY: Holt, Rinehart and Winston.

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks, CA: Sage.

Till, K., Cobley, S., O'Hara, J., Cooke, C., and Chapman, C. (2014). Considering maturation status and relative age in the longitudinal evaluation of junior rugby league players. *Scand. J. Med. Sci. Sports* 24, 569–576. doi: 10.1111/sms.12033

Turnnidge, J., Hancock, D. J., and Côté, J. (2014). The influence of birth date and place of development on youth sport participation. *Scand. J. Med. Sci. Sports* 24, 461–468. doi: 10.1111/sms.12002

Ulbricht, A., Fernandez-Fernandez, J., Mendez-Villanueva, A., and Ferrauti, A. (2015). The relative age effect and physical fitness characteristics in German male tennis players. *J. Sports Sci. Med.* 14, 634–642.

van den Honert, R. (2012). Evidence of the relative age effect in football in Australia. *J. Sports Sci.* 30, 1365–1374. doi: 10.1080/02640414.2012.707329

Wertz, M. S., Nosek, M., McNiesh, S., and Marlow, E. (2011). The composite first person narrative: texture, structure, and meaning in writing phenomenological descriptions. *Int. J. Qual. Stud. Health Well Being* 6, 1–10. doi: 10.3402/qhw.v6i2.5882

Willis, R. (2019). The use of composite narrative to present interview findings. *Qual. Res.* 19, 471–480. doi: 10.1177/1468794118787711

Yin, R. K. (2014). Case Study Research: Design And Methods. Thousand Oaks, CA: Sage.

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Are Soccer and Futsal Affected by the Relative Age Effect? The Portuguese Football Association Case

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A better understanding of the relative age effect (RAE) in youth will increase the awareness of the need for reducing the bias of (de)selection. Thus, we investigated the RAE in youth female and male soccer and futsal players in Portugal, using nationwide data. Birthdates of 5,306 female and 126,285 male soccer players, and 2,437 female and 23,988 male futsal players (U7–U19), registered in Portugal during the season 2019–2020, and Portuguese National teams (from U15 to AA soccer teams and from U17 to AA futsal teams) were analyzed. Data were categorized into age groups and certification levels [no certification, basic football training center, football school, and training institution] of the respective clubs/academies. Birthdates were stratified from the start of the selection year using quartiles (Q) and semesters (S). Differences between the observed and expected birthdate distributions were analyzed using chi-square statistics, and RAEs were calculated using odds ratios (OR). In both soccer and futsal, female players, in the age category U9, RAEs were found (Q1 vs. Q4, OR: 1.49 and 1.84, respectively). In male soccer, differences in the birthdate distribution were observed in all age categories (U7–U19) with significant OR between all comparisons (Q and S). In contrast, an over-representation of young male futsal players (Q1 vs. Q4) was observed only in the age categories U7 and U9 (OR: 1.54 and 1.34, respectively). The stratification by certification level showed a significant RAE for all certification levels in male soccer players. In contrast, in male futsal players, the RAE was significant only in clubs and academies with the highest level. For National teams, the RAE was more pronounced in male soccer, particularly in the U16 and U17 (OR: 9.84 and 12.36, respectively). Data showed a RAE in female and male youth soccer and futsal, particularly in male, younger age categories, and in clubs and academies having a higher certification level, which could be accompanied by a loss of valuable elite players during the youth phase of their careers. Thus, adjustments in the systems and structure of talent identification are recommended to prevent RAE-related discrimination in youth soccer and futsal.

Keywords: birthdate, football, player selection, gender, youth development

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INTRODUCTION

Youth athletic development is complex; it is a highly individual process and is affected by the interdependent factors within a constantly changing environment, such as physical growth, biological maturation, and behavioral development (Bergeron et al., 2015). Consequently, given the association of these factors with age, age plays a key role in this ongoing process.

In most countries, youth athletes are grouped based on chronological age cohorts with fixed cutoff dates aligned with the selection year (for example, January 1 to December 31), or in a window of 2 years (used by several sports organizations, including the Fédération International de Football Association, FIFA). Although this procedure is used to establish age-appropriate training, equalize competitive levels and reduce differences between opponents, it does not account for potentially large maturity-related differences that are possible within an age cohort (Helsen et al., 2005). This can effectively influence sporting talent identification and lead to an increased dropout from sport (Delorme et al., 2011; Breitbach et al., 2014).

Generally, a birthdate closer to the beginning of the year (e.g., in the first 3 months) has been associated with a sporting advantage, resulting in an over-representation of athletes born in that period. This has been defined as the relative age effect (RAE; Barnsley et al., 1985; Wattie et al., 2008). There is a widespread scientific opinion that advanced physical characteristics (e.g., greater body size and muscle mass, and better physical fitness) are most likely accountable for this over-representation of players born in the first quarter of the year (Malina et al., 2004, 2007; Cobley et al., 2009). A wider appreciation of the athletic triangle (i.e., coach, parent, and athlete) and factors beyond the physical should also be considered with regards to the RAE (Hancock et al., 2013; Wattie et al., 2015), particularly as data has demonstrated that the RAE is evident within pre-pubertal age groups, where maturity-related factors should not be a contributing factor (Doncaster et al., 2020).

At this stage, the Portuguese Football Association (FPF) is currently implementing a certification program that considers different levels of certification for youth development clubs and academies. The ultimate aim is to improve players' development quality (up to the age of 19) at the club level, considering both the training process and the entire club or academy's internal processes. Actually, the certification program is considered a priority project for the FPF, since in Portugal, soccer and futsal are popular sports, and the number of registered participants has been continuously increasing over the last years, both on female and male participants (Portugal Football Observatory, 2021).

The RAE has been extensively explored in soccer, but most studies have predominantly focused on professional elite male players, and less is known in other contexts such as female players and futsal athletes (Cobley et al., 2009; Smith et al., 2018). Of note, futsal is the official five-a-side indoor version of soccer. Though, findings are expected to vary according to the sporting context and type, and several other factors, including age, competition level, gender, and player position, are recognized as potential moderators of the RAE (Cobley et al., 2009; Smith et al., 2018). Based on the available evidence, gender and competition level are the most notable RAE moderators, but with inconsistent effects on both genders (Cobley et al., 2009; Romann and Fuchslocher, 2011; Sedano et al., 2015; Smith et al., 2018). Research suggests that the RAE is increasingly prevalent as the level of competition standard improves and on male athletes.

Some studies have explored the RAE using nationwide data (e.g., Finnegan et al., 2017; Romann et al., 2020; Dugdale et al., 2021). However, no study so far has analyzed original data at the level of a National sports governing body structure on both genders and football codes (i.e., soccer and futsal), and including data from National teams.

The purpose of this study was to investigate the RAE in female and male soccer and futsal youth players, across a range of age categories (from U7 to U19), and certification levels of clubs and academies registered in the FPF. Also, the RAE was analyzed in several Portuguese National Teams (soccer and futsal, male and female) from youth to professional adult players.

MATERIALS AND METHODS

Participants and Procedures

In this study, we analyzed the birthdates of 5,306 female and 126,285 male soccer players, and 2,437 female and 23,988 male futsal players, registered with the FPF during the season 2019/2020. Players were categorized into age groups and certification level of their respective clubs or academies (3,018), as defined and classified by the FPF.[1]

The certification process from the FPF evaluates clubs and academies that provide training to young participants in soccer and futsal (up to the age of 19). The evaluation process is based on the following factors: strategic planning and budget; organizational structure and good practices; recruitment; sports training; medical support; school, personal and social monitoring; human resources; facilities and logistics; and, productivity. For the current study, we considered four levels of certification: no certification, basic football training center (BFTC), football school, and training institution.

The female and male Portuguese soccer and futsal National teams' rosters were analyzed dating back to the season 2016/2017. In the FPF, National teams start from U15 to the adult professional level (i.e., AA). Players that were in more than one National Team at least twice were considered in both National Teams. Birthdate data are also publicly available on the internet.[2] Players' birthdates were collected from the FPF official database with permission and approval for treatment and analysis from the Portugal Football School and the Data Protection Office from the FPF.

The cutoff date used for the selection year, for all ages, was January 1st, as this is the same for all soccer and futsal leagues in Portugal, as well as for the National Teams. Birthdates for all players were stratified using quartiles (Q) and semesters (S). Thus, quartiles were organized as follows: from January to March (Q1), April to June (Q2), July to September (Q3),

[1] www.fpf.pt/Institucional/Documentação
[2] www.fpf.pt/Jogadores

and from October to December (Q4), while S1 and S2 included the months from January to June, and July to December, respectively. The expected birthdate distributions were obtained from Statistics Portugal.[3] The gender-, age-, and sport-specific reference population (RP) distributions were calculated considering the birth years from the youngest to the oldest players.

Statistical Analysis

The observed birthdate distributions of all players were calculated for each quarter and semester of the year and presented as absolute and relative frequencies, for each age group, gender, and certification level in both soccer and futsal. Chi-square goodness-of-fit tests were used to compare the observed and expected birthdate distributions across quartiles. As Chi-squared statistics cannot reveal the magnitude and direction of an existing relationship, we additionally calculated the odds ratios (OR) and 95% CI for the quartiles (Q1, Q2, and Q3) and semester (S1), with the youngest group as reference (i.e., Q4 and S2). We also applied the Benjamini and Hochberg (1995) procedure for multiple testing correction, and reported the false discovery rate (FDR) adjusted *p*-values. FDR-adjusted *p*-values lower than 0.05 were assumed to be statistically significant. We assumed the existence of a RAE if the 95% CI range did not include a value ≤1, and interpreted an OR 1.22 ≤ OR < 1.86 as small, 1.86 ≤ OR <3.00 as medium, and OR ≥ 3.00 as large (Olivier and Bell, 2013). All statistical analyses were conducted using R statistical software (version 4.0.2, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

For the youth soccer and futsal players (age categories from U7 to U19), **Table 1** displays the frequency and percentage distributions of players' birth quartiles for each gender.

[3]www.ine.pt

TABLE 1 | Birthdate distribution by quarter of the year for female and male youth soccer and futsal players registered with the Portuguese Football Association.

Age category	*n*	Birthdate distribution, *n* (%)				χ^2	FDR-adjusted *p*
		Q1	Q2	Q3	Q4		
Female							
RP (2001–2015)	*733,119*	*176,204 (24.0)*	*178,562 (24.4)*	*193,580 (26.4)*	*184,773 (25.2)*		
Soccer							
U7	180	46 (25.6)	52 (28.9)	53 (29.4)	29 (16.1)	8.23	0.096
U9	501	152 (30.3)	140 (27.9)	102 (20.4)	107 (21.4)	20.81	**<0.001**
U11	811	209 (25.8)	209 (25.8)	200 (24.7)	193 (23.8)	3.25	0.512
U13	904	226 (25.0)	242 (26.8)	219 (24.2)	217 (24.0)	4.65	0.353
U15	1,096	266 (24.3)	269 (24.5)	305 (27.8)	256 (23.4)	2.36	0.644
U17	1,031	243 (23.6)	270 (26.2)	273 (26.5)	245 (23.8)	2.36	0.644
U19	783	165 (21.1)	201 (25.7)	208 (26.6)	209 (26.7)	4.11	0.406
Futsal							
U7	60	16 (26.7)	16 (26.7)	13 (21.7)	15 (25.0)	0.82	0.846
U9	184	58 (31.5)	45 (24.5)	48 (26.1)	33 (17.9)	8.16	**0.043**
U11	257	71 (27.6)	59 (23.0)	67 (26.1)	60 (23.3)	1.95	0.583
U13	324	86 (26.5)	65 (20.1)	92 (28.4)	81 (25.0)	3.79	0.285
U15	424	110 (25.9)	113 (26.7)	109 (25.7)	92 (21.7)	3.70	0.295
U17	576	143 (24.8)	143 (24.8)	150 (26.0)	140 (24.3)	0.42	0.937
U19	612	166 (27.1)	131 (21.4)	162 (26.5)	153 (25.0)	4.63	0.201
Male							
RP (2001–2015)	*776,006*	*186,232 (24.0)*	*189,874 (24.5)*	*204,611 (26.4)*	*195,289 (25.2)*		
Soccer							
U7	6,759	1,876 (27.8)	1,770 (26.2)	1,772 (26.2)	1,341 (19.8)	124.15	**<0.001**
U9	15,348	4,199 (27.4)	3,812 (24.8)	3,844 (25.0)	3,493 (22.8)	118.56	**<0.001**
U11	23,372	5,923 (25.3)	5,808 (24.9)	6,048 (25.9)	5,593 (23.9)	35.28	**<0.001**
U13	23,824	6,080 (25.5)	5,738 (24.1)	6,356 (26.7)	5,650 (23.7)	45.21	**<0.001**
U15	22,502	6,100 (27.1)	5,710 (25.4)	5,620 (25.0)	5,072 (22.5)	176.43	**<0.001**
U17	19,851	5,408 (27.2)	5,089 (25.6)	4,930 (24.8)	4,424 (22.3)	181.22	**<0.001**
U19	14,629	3,959 (27.1)	3,777 (25.8)	3,624 (24.8)	3,269 (22.3)	128.46	**<0.001**
Futsal							
U7	1,285	385 (30.0)	319 (24.8)	318 (24.7)	263 (20.5)	31.66	**<0.001**
U9	2,708	753 (27.8)	689 (25.4)	676 (25.0)	590 (21.8)	31.72	**<0.001**
U11	3,856	921 (23.9)	930 (24.1)	1,024 (26.6)	981 (25.4)	0.38	0.944
U13	4,412	1,084 (24.6)	1,102 (25.0)	1,154 (26.2)	1,072 (24.3)	2.46	0.664
U15	4,519	1,091 (24.1)	1,075 (23.8)	1,185 (26.2)	1,168 (25.8)	1.76	0.751
U17	4,067	965 (23.7)	1,026 (25.2)	1,075 (26.4)	1,001 (24.6)	1.58	0.770
U19	3,141	732 (23.3)	757 (24.1)	880 (28.0)	772 (24.6)	4.48	0.362

FDR, false discovery rate; RP, reference population. Values in bold are significant.

In female players, the RAE was only evident within the U9 age category, in which the birthdate distribution differed significantly from the Portuguese population's distribution. The descriptive OR comparisons are presented in **Table 2**. Both U9 female age categories (soccer and futsal) revealed significant but small OR for comparing Q1 and Q4, and between semesters.

In male soccer, results display a different distribution from the Portuguese population's distribution in all age categories (**Table 1**). More players were born in the first quarters (i.e., over-represented), as revealed by the significant OR for the comparison between Q1 vs. Q4. The OR for the remaining comparisons were also significant, but with smaller magnitudes. Finally, male futsal results showed a different distribution from the Portuguese population's distribution only in the two youngest age categories (U7 and U9). Again, we observed an over-representation of young male futsal players (U7 and U9) born in the first quarters, supported by the significant OR (1.54 and 1.34, respectively; **Table 2**).

Table 3 shows the distribution by quarters of the players' dates of birth according to the different certification levels of clubs and academies.

Results for the female players showed that for both soccer and futsal, only in clubs and academies with no certification, the birthdate distribution differed significantly from the distribution in the RP, but the effect was weak (**Table 4**).

There was a significant RAE for all certification levels in male soccer players, and the OR only slightly declined across comparisons. In male futsal players, the RAE was significant only in clubs and academies with training institution certification.

The birthdate distributions by quarters and OR for the National Teams are presented in **Tables 5** and **6**, respectively.

The χ^2-statistics showed a significant difference between the relative age quarter distributions compared with the reference population only in the female AA soccer team, the male U19 futsal team, and in all male soccer teams (except the AA team). However, there was a stronger over-representation of young male soccer players born in the first quarters in the

TABLE 2 | Odds ratios (OR; 95% CI) according to players' age category by gender for youth soccer and futsal players examining relative age effect (RAE).

Age category	Odds ratios (95% CI)			
	Q1 vs. Q4	**Q2 vs. Q4**	**Q3 vs. Q4**	**S1 vs. S2**
Female				
Soccer				
U7	**1.66 (1.05–2.65)**	**1.86 (1.18–2.92)**	**1.74 (1.11–2.74)**	1.27 (0.95–1.71)
U9	**1.49 (1.16–1.91)**	**1.35 (1.05–1.74)**	0.91 (0.69–1.19)	**1.49 (1.25–1.78)**
U11	1.14 (0.93–1.38)	1.12 (0.92–1.36)	0.99 (0.81–1.21)	1.13 (0.99–1.30)
U13	1.09 (0.91–1.32)	1.15 (0.96–1.39)	0.96 (0.80–1.16)	1.14 (1.00–1.30)
U15	1.09 (0.92–1.29)	1.09 (0.92–1.29)	1.14 (0.96–1.34)	1.02 (0.90–1.15)
U17	1.04 (0.87–1.24)	1.14 (0.96–1.36)	1.06 (0.89–1.26)	1.06 (0.93–1.19)
U19	0.83 (0.67–1.02)	1.00 (0.82–1.21)	0.95 (0.78–1.15)	0.94 (0.81–1.08)
Futsal				
U7	1.12 (0.55–2.26)	1.10 (0.55–2.23)	0.83 (0.39–1.74)	1.22 (0.73–2.02)
U9	**1.84 (1.20–2.83)**	1.41 (0.90–2.21)	1.39 (0.89–2.16)	**1.36 (1.01–1.81)**
U11	1.24 (0.88–1.75)	1.02 (0.71–1.46)	1.07 (0.75–1.51)	1.09 (0.85–1.39)
U13	1.11 (0.82–1.51)	0.83 (0.60–1.15)	1.08 (0.80–1.46)	0.93 (0.75–1.16)
U15	1.25 (0.95–1.65)	1.27 (0.97–1.67)	1.13 (0.86–1.49)	1.18 (0.98–1.43)
U17	1.07 (0.85–1.35)	1.06 (0.84–1.33)	1.02 (0.81–1.29)	1.05 (0.89–1.24)
U19	1.14 (0.91–1.42)	0.89 (0.70–1.12)	1.01 (0.81–1.26)	1.01 (0.86–1.18)
Male				
Soccer				
U7	**1.47 (1.37–1.57)**	**1.36 (1.26–1.46)**	**1.26 (1.17–1.35)**	**1.25 (1.19–1.31)**
U9	**1.26 (1.20–1.32)**	**1.12 (1.07–1.18)**	**1.05 (1.00–1.10)**	**1.16 (1.12–1.20)**
U11	**1.11 (1.07–1.15)**	**1.07 (1.03–1.11)**	**1.03 (1.00–1.07)**	**1.07 (1.04–1.10)**
U13	**1.13 (1.09–1.17)**	**1.04 (1.01–1.08)**	**1.07 (1.04–1.11)**	**1.05 (1.02–1.07)**
U15	**1.26 (1.21–1.31)**	**1.16 (1.11–1.20)**	**1.06 (1.02–1.10)**	**1.17 (1.14–1.21)**
U17	**1.28 (1.23–1.33)**	**1.18 (1.14–1.23)**	**1.06 (1.02–1.11)**	**1.19 (1.16–1.23)**
U19	**1.27 (1.21–1.33)**	**1.19 (1.13–1.25)**	**1.06 (1.01–1.11)**	**1.19 (1.15–1.23)**
Futsal				
U7	**1.54 (1.31–1.80)**	**1.25 (1.06–1.47)**	1.15 (0.98–1.36)	**1.29 (1.15–1.44)**
U9	**1.34 (1.20–1.49)**	**1.20 (1.08–1.34)**	1.09 (0.98–1.22)	**1.21 (1.12–1.31)**
U11	0.98 (0.90–1.08)	0.98 (0.89–1.07)	1.00 (0.91–1.09)	0.98 (0.92–1.05)
U13	1.06 (0.97–1.15)	1.06 (0.97–1.15)	1.03 (0.95–1.12)	1.04 (0.98–1.11)
U15	0.98 (0.90–1.06)	0.95 (0.87–1.03)	0.97 (0.89–1.05)	0.98 (0.92–1.04)
U17	1.01 (0.93–1.10)	1.05 (0.97–1.15)	1.02 (0.94–1.12)	1.02 (0.96–1.08)
U19	0.99 (0.90–1.10)	1.01 (0.91–1.12)	1.09 (0.99–1.20)	0.96 (0.89–1.03)

Values in bold are significant.

TABLE 3 | Birthdate distribution for female and male youth soccer and futsal players in Portugal according to the different certification levels of clubs and academies, as classified by the Portuguese Football Association.

Certification level	*n*	Birthdate distribution, *n* (%)				χ^2	FDR-adjusted *p*
		Q1	Q2	Q3	Q4		
Female							
RP (2001–2015)	*733,119*	*176,204 (24.0)*	*178,562 (24.4)*	*193,580 (26.4)*	*184,773 (25.2)*		
Soccer							
No certification	4,490	1,108 (24.7)	1,187 (26.4)	1,139 (25.4)	1,056 (23.5)	15.63	**0.004**
BFTC	291	76 (26.1)	70 (24.1)	77 (26.5)	68 (23.4)	0.93	0.888
Football school	300	72 (24.0)	66 (22.0)	89 (29.7)	73 (24.3)	1.98	0.715
Training institution	225	51 (22.7)	60 (26.7)	55 (24.4)	59 (26.2)	1.09	0.874
Futsal							
No certification	2,211	593 (26.8)	512 (23.2)	583 (26.4)	523 (23.7)	10.55	**0.014**
BFTC	41	12 (29.3)	11 (26.8)	11 (26.8)	7 (17.1)	1.65	0.766
Football school	0	---	---	---	---		
Training institution	185	45 (24.3)	49 (26.5)	47 (25.4)	44 (23.8)	0.57	0.932
Male							
RP (2001–2015)	*776,006*	*186,232 (24.0)*	*189,874 (24.5)*	*204,611 (26.4)*	*195,289 (25.2)*		
Soccer							
No certification	74,083	19,265 (26.0)	18,336 (24.8)	19,131 (25.8)	17,351 (23.4)	224.54	**<0.001**
BFTC	6,850	1,810 (26.4)	1,753 (25.6)	1,741 (25.4)	1,546 (22.6)	41.01	**<0.001**
Football school	10,871	2,812 (25.9)	2,746 (25.3)	2,774 (25.5)	2,539 (23.4)	35.73	**<0.001**
Training institution	34,481	9,658 (28.0)	8,869 (25.7)	8,548 (24.8)	7,406 (21.5)	472.08	**<0.001**
Futsal							
No certification	17,678	4,295 (24.3)	4,318 (24.4)	4,655 (26.3)	4,410 (24.9)	1.01	0.880
BFTC	1,858	489 (26.3)	447 (24.1)	472 (25.4)	450 (24.2)	5.61	0.246
Football school	1,417	346 (24.4)	335 (23.6)	408 (28.8)	328 (23.1)	5.96	0.224
Training institution	3,035	801 (26.4)	798 (26.3)	777 (25.6)	659 (21.7)	26.43	**<0.001**

BFTC, basic football training center; FDR, false discovery rate; RP, reference population. Values in bold are significant.

U16 and U17 teams, as OR progressively declined as the teams' age category increased (**Table 6**).

DISCUSSION

This study investigated the RAE in soccer and futsal players register in Portugal across several age categories, according to gender and certification level of clubs and academies registered with the FPF. The analysis also included data from players selected for National teams. The major findings of this study showed that: (i) in male soccer players, there was a statistically significant RAE in all youth age groups (including the National teams from U15 to U21); (ii) in male futsal players, the RAE was observed only in the younger age groups (U7 and U9); (iii) the RAE was less prevalent among females; and (iv) although the RAE was found among male soccer players irrespectively of the certification levels, it was more prevalent in the clubs and academies classified in the highest level of certification.

The results presented here are consistent with those from prior studies showing that the RAE is prevalent and persistent in male players worldwide (Cobley et al., 2008; Jimenez and Pain, 2008; Mujika et al., 2009; Williams, 2010). Though, the RAE has also been found in female athletes, but results are still unclear regarding the real effect on soccer and futsal. In fact, while some studies have reported no significant RAE (Delorme et al., 2009; Romann and Fuchslocher, 2011; Júnior et al., 2018), the aggregated results reported in a recent meta-analysis supported a small RAE for soccer (OR = 1.31; Smith et al., 2018). Consistent with these findings, we only detected significant RAE in the female age category U9 (soccer and futsal). This over-representation of players born at the beginning of the year for one of the youngest age groups (U9) lends further support to the idea suggested in previous studies that initial enrolment bias facilitated by parents may explain the RAE at early ages (Hancock et al., 2013). Also, it is possible that the difference observed by gender on RAE can be related to the level of attraction of a sport for girls and boys and variations of competition levels (Baker et al., 2010). Götze and Hoppe (2021) suggest that other reason could be a less intense competition within a team to make the starting line-up.

In the current study, there was a predominance of the RAE in male soccer compared with the effect found in male futsal players. These divergent findings could be related to factors such as the sport's popularity within Portugal or physiological and psychological conditions (Musch and Grondin, 2001; Cote et al., 2006; Mccarthy and Collins, 2014). In addition, sports regarded as popular are likely to increase competitiveness levels from an early age, which has been shown to exacerbate the RAE (Bezuglov et al., 2019). At the club level, Doncaster et al. (2020) found a RAE within a range of sports, but more prevalent in sports that may be regarded as popular, such as male soccer. It has been argued that if the process of talent identification is focused on the short-term success, it may contribute to this pattern.

TABLE 4 | Odds ratios (95% CI) by gender and certification level (according to the certification of clubs and academies as classified by the Portuguese Football Association.) for youth soccer and futsal players examining RAE.

Certification level	Odds ratios (95% CI)			
	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	S1 vs. S2
Female				
Soccer				
No certification	**1.10 (1.01–1.20)**	**1.16 (1.07–1.26)**	1.03 (0.95–1.12)	**1.12 (1.05–1.18)**
BFTC	1.17 (0.84–1.63)	1.07 (0.76–1.49)	1.08 (0.78–1.50)	1.07 (0.85–1.35)
Football school	1.03 (0.75–1.43)	0.94 (0.67–1.31)	1.16 (0.85–1.59)	0.91 (0.72–1.14)
Training institution	0.91 (0.62–1.32)	1.05 (0.73–1.51)	0.89 (0.62–1.28)	1.04 (0.80–1.35)
Futsal				
No certification	**1.19 (1.06–1.34)**	1.01 (0.90–1.14)	1.06 (0.95–1.20)	1.07 (0.98–1.16)
BFTC	1.80 (0.71–4.57)	1.63 (0.63–4.19)	1.50 (0.58–3.87)	1,36 (0.74–2.53)
Football school	---	---	---	---
Training institution	1.07 (0.71–1.63)	1.15 (0.77–1.73)	1.02 (0.68–1.54)	1.10 (0.83–1.47)
Male				
Soccer				
No certification	**1.16 (1.14–1.19)**	**1.09 (1.06–1.11)**	**1.05 (1.03–1.08)**	**1.10 (1.08–1.11)**
BFTC	**1.23 (1.15–1.31)**	**1.17 (1.09–1.25)**	**1.07 (1.00–1.15)**	**1.15 (1.10–1.21)**
Football school	**1.16 (1.10–1.23)**	**1.11 (1.05–1.17)**	**1.04 (1.00–1.10)**	**1.11 (1.07–1.16)**
Training institution	**1.37 (1.33–1.41)**	**1.23 (1.19–1.27)**	**1.10 (1.07–1.14)**	**1.23 (1.21–1.26)**
Futsal				
No certification	1.02 (0.98–1.07)	1.01 (0.97–1.05)	1.01 (0.97–1.05)	1.01 (0.98–1.04)
BFTC	**1.14 (1.00–1.30)**	1.02 (0.90–1.16)	1.00 (0.88–1.14)	1.08 (0.99–1.18)
Football school	1.11 (0.95–1.29)	1.05 (0.90–1.22)	**1.19 (1.03–1.37)**	0.98 (0.89–1.09)
Training institution	**1.27 (1.15–1.41)**	**1.25 (1.12–1.38)**	**1.13 (1.01–1.25)**	**1.18 (1.10–1.27)**

BFTC, basic football training center. Values in bold are significant.

However, it should be acknowledged that the determinants and requirements for success in top-level soccer are non-linear and multifactorial (Skorski et al., 2016). Also, coaches' role in the genesis of RAEs and their subsequent amplification has been highlighted (Hancock et al., 2013). As key social agents, coaches influence RAE through Pygmalion effects, i.e., wrongly influenced and based on physical maturity, coaches may develop higher expectations for relatively older children compared to peers (Hancock et al., 2013).

Our findings indicated that the RAE was not present in the male adult professional soccer team (National AA-Team), and the OR were higher between Q1 and Q4 in U16 and U17 than in younger and older age groups. These results were expected because in professional adult teams all players should be able to perform at a high level (i.e., comparable levels in physical performance), have small disparities in growth and maturation (Lovell et al., 2015), and high levels of exposure to training. All these factors should be considered in relation to the reduced prevalence of the RAE. Moreover, a longitudinal investigation into the RAE in an English professional soccer club showed that Q4 male soccer players were approximately four times more likely to achieve adult professional status than Q1 player's, despite the reduced number of players within Q4 (Kelly et al., 2019). This reinforces the changes associated with the transition from youth to professional adult level, which has implications in the RAE, as reported by others (Brustio et al., 2018; Lupo et al., 2019; Dugdale et al., 2021).

In youth soccer players from Portuguese clubs and academies, the RAE was also observed across all age categories, but the highest OR was found between Q1 and Q4 in U7 soccer players. Similar to these results, prior studies have also reported that the extent of the RAE decreases with increasing age (Helsen et al., 2005; Lovell et al., 2015; Doncaster et al., 2020). There is evidence that the RAE decreases with age after adolescence (Cobley et al., 2009; Brustio et al., 2018). Actually, for the German national male youth soccer teams, it was reported that the RAE decreased with increasing age categories from U16 to the adult professional team (Skorski et al., 2016). Also, our finding highlights that the RAE is evident within pre-pubertal age groups, where maturity-related factors should not be a contributing factor, as also showed by Doncaster et al. (2020).

The lower prevalence of the RAE within futsal may be explained by the fact that futsal is less popular in Portugal than soccer, taking into account the broad differences in the number of registered players in both sports (according to 2019 data from registered male players, from the overall male Portugal population aged 5–19 years, 22% play soccer, while only 5% play futsal). Also, some players may have transitioned to futsal after a period in soccer where they did not excel, but they developed physical attributes, which may dilute the maturity disparities associated with chronological age differences (Lago-Fuentes et al., 2020). Also, as the official futsal laws of the game[4] allow unlimited changes of players during the match, less mature players might have more chances to develop technical and tactical

[4]https://www.fifa.com

TABLE 5 | Birthdate distribution for female and male soccer and futsal players in Portuguese National Teams.

National team	*n*	Birthdate distribution, *n* (%)				χ^2	FDR-adjusted *p*
		Q1	Q2	Q3	Q4		
Female							
RP (1979–2006)	*1,589,225*	*386,041 (24.3)*	*400,367 (25.2)*	*410,601 (25.8)*	*392,216 (24.7)*		
Soccer							
U15	56	19 (33.9)	17 (30.4)	14 (25.0)	6 (10.7)	7.17	0.144
U16	91	23 (25.3)	30 (33.0)	21 (23.1)	17 (18.7)	3.81	0.430
U17	82	26 (31.7)	23 (28.0)	17 (20.7)	16 (19.5)	3.84	0.430
U19	81	25 (30.9)	19 (23.5)	20 (24.7)	17 (21.0)	2.03	0.567
AA	57	6 (10.5)	23 (40.4)	17 (29.8)	11 (19.3)	10.66	**0.034**
RP (1984–2007)	*1,345,949*	*326,583 (24.3)*	*336,699 (25.0)*	*348,914 (25.9)*	*333,753 (24.8)*		
Futsal							
U17	30	10 (33.3)	9 (30.0)	6 (20.0)	5 (16.7)	2.52	0.664
U18	14	7 (50.0)	3 (21.4)	1 (7.1)	3 (21.4)	5.86	0.227
U19	28	12 (42.9)	7 (25.0)	4 (14.3)	5 (17.9)	6.00	0.224
AA	36	10 (27.8)	11 (30.6)	7 (19.4)	8 (22.2)	1.30	0.830
Male							
RP (1978–2006)	*1,864,240*	*451,770 (24.2)*	*473,909 (25.4)*	*480,733 (25.8)*	*457,828 (24.6)*		
Soccer							
U15	79	44 (55.7)	20 (25.3)	9 (11.4)	6 (7.6)	47.88	**<0.001**
U16	122	68 (55.7)	33 (27.0)	14 (11.5)	7 (5.7)	77.38	**<0.001**
U17	114	61 (53.5)	37 (32.5)	11 (9.6)	5 (4.4)	72.94	**<0.001**
U18	131	58 (44.3)	42 (32.1)	19 (14.5)	12 (9.2)	43.10	**<0.001**
U19	147	63 (42.9)	44 (29.9)	25 (17.0)	15 (10.2)	38.94	**<0.001**
U20	120	46 (38.3)	34 (28.3)	23 (19.2)	17 (14.2)	17.56	**0.002**
U21	80	32 (40.0)	21 (26.3)	12 (15.0)	15 (18.8)	12.94	**0.013**
AA	61	13 (21.3)	14 (23.0)	14 (23.0)	20 (32.8)	2.23	0.683
RP (1979–2005)	*1,723,059*	*417,166 (24.2)*	*437,945 (25.4)*	*444,923 (25.8)*	*423,025 (24.6)*		
Futsal							
U17	70	19 (27.1)	29 (41.4)	9 (12.9)	13 (18.6)	12.89	**0.013**
U18	26	6 (23.1)	12 (46.2)	4 (15.4)	4 (15.4)	6.40	0.196
U19	53	14 (26.4)	25 (47.2)	7 (13.2)	7 (13.2)	16.02	**0.003**
U21	48	12 (25.0)	18 (37.5)	10 (20.8)	8 (16.7)	4.45	0.362
AA	34	10 (29.4)	9 (26.5)	8 (23.5)	7 (20.6)	0.68	0.920

FDR, false discovery rate; RP, reference population. Values in bold are significant.

skills, offsetting their physical disadvantages when compared with more mature peers.

Finally, our findings indicated that in male soccer and futsal, the RAE extension increased as the certification level of clubs and academies improved. This was particularly highlighted in soccer. This might suggest that clubs and academies certified as a training institution also have the means to select more the players than the lower level certification clubs and academies, thus taking advantage of the potential beneficial effect of an over-representation of the chronologically older players. No comparisons with other studies are possible, as this is the first study reporting the RAE according to each club or academy classification level, which is attributed based on a specific certification process implemented by the FPF. Of note, when looking into the RAE on male Scottish youth soccer players, Dugdale et al. (2021) showed an influence of the playing level within male soccer academy structures.

In Portugal, clubs and academies are the primary talent development settings in soccer and futsal. Though, the decisions made about who is selected to be part of these structures at an early age will impact the subsequent long-term outputs from the sports development systems or programs implemented. Therefore, these findings are essential to better understand why specific individuals might be more likely to be selected into a soccer or futsal team. For example, in a nationwide analysis of Swiss child and youth football players, Romann et al. (2020) found a RAE at the grassroots level and that the use a selection system seems to increase RAEs created by coach's selection. Also, Dugdale et al. (2021) on their analysis of playing levels and ages of male Scottish youth soccer players found a bias in selecting individuals born earlier in the selection year within academies, but not at amateur level.

The current study supports and extends upon the existing RAE literature including a comprehensive overview of birthdate distributions across multiple age groups in both female and male soccer and futsal players, alongside the National teams. This was a complete nationwide database, with large sample size, and the certification level attributed to youth clubs and academies was also examined as a factor potentially associated with the RAE. However, the absence of anthropometric and performance data, which could provide a better description of the RAE phenomenon, is a limitation of this study.

TABLE 6 | Odds ratios (95% CI) by gender and National Team, organized by the Portuguese Football Association, for female and male soccer and futsal players.

National team	Odds ratios (95% CI)			
	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	S1 vs. S2
Female				
Soccer				
U15	**3.22 (1.28–8.06)**	**2.78 (1.09–7.04)**	2.23 (0.86–5.80)	**1.84 (1.06–3.17)**
U16	1.37 (0.73–2.57)	1.73 (0.95–3.13)	1.18 (0.62–2.24)	1.42 (0.94–2.16)
U17	1.65 (0.89–3.08)	1.41 (0.74–2.67)	1.01 (0.51–2.01)	1.52 (0.97–2.36)
U19	1.49 (0.81–2.77)	1.09 (0.57–2.11)	1.12 (0.59–2.15)	1.21 (0.78–1.88)
AA	0.55 (0.20–1.50)	2.05 (0.99–4.20)	1.48 (0.69–3.15)	1.06 (0.63–1.78)
Futsal				
U17	2.04 (0.70–5.98)	1.78 (0.60–5.32)	1.15 (0.35–3.76)	1.78 (0.85–3.74)
U18	2.38 (0.62–9.22)	0.99 (0.20–4.91)	0.32 (0.03–3.07)	2.57 (0.81–8.20)
U19	2.45 (0.86–6.96)	1.39 (0.44–4.37)	0.77 (0.21–2.85)	2.17 (0.98–4.80)
AA	1.28 (0.50–3.24)	1.36 (0.55–3.39)	0.84 (0.30–2.31)	1.44 (0.74–2.80)
Male				
Soccer				
U15	**7.43 (3.17–17.44)**	**3.22 (1.29–8.02)**	1.43 (0.51–4.01)	**4.33 (2.47–7.59)**
U16	**9.84 (4.52–21.43)**	**4.55 (2.01–10.30)**	1.90 (0.77–4.72)	**4.88 (3.05–7.80)**
U17	**12.36 (4.97–30.77)**	**7.15 (2.81–18.19)**	2.10 (0.73–6.03)	**6.21 (3.66–10.53)**
U18	**4.90 (2.63–9.12)**	**3.38 (1.78–6.42)**	1.51 (0.73–3.11)	**3.27 (2.19–4.89)**
U19	**4.26 (2.42–7.47)**	**2.83 (1.58–5.09)**	1.59 (0.84–3.01)	**2.71 (1.89–3.90)**
U20	**2.74 (1.57–4.78)**	**1.93 (1.08–3.46)**	1.29 (0.69–2.41)	**2.03 (1.39–2.96)**
U21	**2.16 (1.17–3.99)**	1.35 (0.70–2.62)	0.76 (0.36–1.63)	**1.99 (1.25–3.16)**
AA	0.66 (0.33–1.32)	0.68 (0.34–1.34)	0.67 (0.34–1.32)	0.81 (0.49–1.33)
Futsal				
U17	1.48 (0.73–3.00)	**2.15 (1.12–4.14)**	0.66 (0.28–1.54)	**2.21 (1.34–3.67)**
U18	1.52 (0.43–5.39)	2.90 (0.93–8.98)	0.95 (0.24–3.80)	2.28 (0.99–5.25)
U19	2.03 (0.82–5.02)	**3.45 (1.49–7.98)**	0.95 (0.33–2.71)	**2.83 (1.54–5.21)**
U21	1.52 (0.62–3.72)	2.17 (0.95–5.00)	1.19 (0.47–3.01)	1.69 (0.94–3.03)
AA	1.45 (0.55–3.81)	1.24 (0.46–3.33)	1.09 (0.39–3.00)	1.29 (0.65–2.53)

Values in bold are significant.

CONCLUSION

Understanding the prevalence of RAE across several age categories in both female and male soccer and futsal players in a nationwide analysis will contribute to the discussion and implementation of national strategies for reducing this bias and other confounding factors of (de)selection. Also, it contributes toward a more systematic approach to talent identification and development in the plural contexts of the different certification levels of the clubs and academies, which are responsible for the players' development. This study highlighted an observed RAE in male soccer, young male futsal players, and young female soccer and futsal players in Portugal. Interestingly, the RAE was observed in male soccer players for clubs and academies irrespectively of the certification level, although with a higher effect on the highest certification level. In male futsal players, the RAE was detected only in clubs and academies with training institution certification. For National teams, the RAE was prevalent in all soccer male teams from the U15 to U21. Despite the descriptive nature of the data, the results show possible questions for future research and highlight the need for an improved understanding of the factors influencing the RAE at a national level, beyond physical characteristics, using an integrated approach.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: data was obtained from a third party. Requests to access the data analyzed in this study should be directed to Data Protection Office, Portuguese Football Association (dpo@fpf.pt).

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Portugal Football School and the Data Protection Office from the Portuguese Football Association. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

PF, JB, and AS contributed to the conceptualization and design of the study. MG and MB performed the data collection. PF and MB performed the data analysis. PF wrote the original draft. All authors contributed to the article and approved the submitted version.

REFERENCES

Baker, J., Schorer, J., and Cobley, S. (2010). Relative age effects: an inevitable consequence of elite sport? *Sportwissenschaft* 40, 26–30. doi: 10.1007/s12662-009-0095-2

Barnsley, R., Thompson, A., and Barnsley, P. (1985). Hockey success and birthdate: the RAE. *Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Benjamini, Y., and Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J. R. Stat. Soc. B. Methodol.* 57, 289–300.

Bergeron, M. F., Mountjoy, M., Armstrong, N., Chia, M., Cote, J., Emery, C. A., et al. (2015). International olympic committee consensus statement on youth athletic development. *Br. J. Sports Med.* 49, 843–851. doi: 10.1136/bjsports-2015-094962

Bezuglov, E. N., Nikolaidis, P. T., Khaitin, V., Usmanova, E., Luibushkina, A., Repetiuk, A., et al. (2019). Prevalence of relative age effect in Russian soccer: the role of chronological age and performance. *Int. J. Environ. Res. Public Health* 16:4055. doi: 10.3390/ijerph16214055

Breitbach, S., Tug, S., and Simon, P. (2014). Conventional and genetic talent identification in sports: will recent developments trace talent? *Sports Med.* 44, 1489–1503. doi: 10.1007/s40279-014-0221-7

Brustio, P. R., Lupo, C., Ungureanu, A. N., Frati, R., Rainoldi, A., and Boccia, G. (2018). The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. *PLoS One* 13:e0196253. doi: 10.1371/journal.pone.0196253

Cobley, S., Baker, J., Wattie, N., and Mckenna, J. (2009). Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cobley, S. P., Schorer, J., and Baker, J. (2008). Relative age effects in professional German soccer: a historical analysis. *J. Sports Sci.* 26, 1531–1538. doi: 10.1080/02640410802298250

Cote, J., Macdonald, D. J., Baker, J., and Abernethy, B. (2006). When "where" is more important than "when": birthplace and birthdate effects on the achievement of sporting expertise. *J. Sports Sci.* 24, 1065–1073. doi: 10.1080/02640410500432490

Delorme, N., Boiche, J., and Raspaud, M. (2009). The relative age effect in elite sport: the French case. *Res. Q. Exerc. Sport* 80, 336–344. doi: 10.1080/02701367.2009.10599568

Delorme, N., Chalabaev, A., and Raspaud, M. (2011). Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand. J. Med. Sci. Sports* 21, 120–128. doi: 10.1111/j.1600-0838.2009.01060.x

Doncaster, G., Medina, D., Drobnic, F., Gomez-Diaz, A. J., and Unnithan, V. (2020). Appreciating factors beyond the physical in talent identification and development: insights from the fc Barcelona sporting model. *Front. Sports Act. Living* 2:91. doi: 10.3389/fspor.2020.00091

Dugdale, J. H., McRobert, A. P., and Unnithan, V. B. (2021). "He's just a wee laddie": the relative age effect in male Scottish soccer. *Front. Psychol.* 12:633469. doi: 10.3389/fpsyg.2021.633469

Finnegan, L., Richardson, D., Littlewood, M., and McArdle, J. (2017). The influence of date and place of birth on youth player selection to a national football association elite development programme. *Sci. Med. Football* 1, 30–39. doi: 10.1080/02640414.2016.1254807

Götze, M., and Hoppe, M. W. (2021). Relative age effect in elite German soccer: influence of gender and competition level. *Front. Psychol.* 11:587023. doi: 10.3389/fpsyg.2020.587023

Hancock, D. J., Adler, A. L., and Cote, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Helsen, W. F., Van Winckel, J., and Williams, A. M. (2005). The relative age effect in youth soccer across Europe. *J. Sports Sci.* 23, 629–636. doi: 10.1080/02640410400021310

Jimenez, I. P., and Pain, M. T. (2008). Relative age effect in Spanish association football: its extent and implications for wasted potential. *J. Sports Sci.* 26, 995–1003. doi: 10.1080/02640410801910285

Júnior, V. R. M., Alves, I. V. G., Galatti, L. R., and Marques, R. F. R. (2018). The relative age effect on Brazilian elite futsal: men and women scenarios. *Motriz Rev. Educ. Fis.* 23. doi: 10.1590/s1980-6574201700030016

Kelly, A. L., Wilson, M. R., Gough, L. A., Knapman, H., Morgan, P., Cole, M., et al. (2019). A longitudinal investigation into the relative age effect in an English professional football club: exploring the 'underdog hypothesis'. *Sci. Med. Football* 4, 111–118. doi: 10.1080/24733938.2019.1694169

Lago-Fuentes, C., Rey, E., Padron-Cabo, A., Prieto-Troncoso, J., and Garcia-Nunez, J. (2020). The relative age effect in professional futsal players. *J. Hum. Kinet.* 72, 173–183. doi: 10.2478/hukin-2019-0105

Lovell, R., Towlson, C., Parkin, G., Portas, M., Vaeyens, R., and Cobley, S. (2015). Soccer player characteristics in english lower-league development programmes: the relationships between relative age, maturation, anthropometry and physical fitness. *PLoS One* 10:e0137238. doi: 10.1371/journal.pone.0137238

Lupo, C., Boccia, G., Ungureanu, A. N., Frati, R., Marocco, R., and Brustio, P. R. (2019). The beginning of senior career in team sport is affected by relative age effect. *Front. Psychol.* 10:1465. doi: 10.3389/fpsyg.2019.01465

Malina, R. M., Eisenmann, J. C., Cumming, S. P., Ribeiro, B., and Aroso, J. (2004). Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *Eur. J. Appl. Physiol.* 91, 555–562. doi: 10.1007/s00421-003-0995-z

Malina, R. M., Ribeiro, B., Aroso, J., and Cumming, S. P. (2007). Characteristics of youth soccer players aged 13-15 years classified by skill level. *Br. J. Sports Med.* 41, 290–295. doi: 10.1136/bjsm.2006.031294

Mccarthy, N., and Collins, D. (2014). Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road? *J. Sports Sci.* 32, 1604–1610. doi: 10.1080/02640414.2014.908322

Mujika, I., Vaeyens, R., Matthys, S. P., Santisteban, J., Goiriena, J., and Philippaerts, R. (2009). The relative age effect in a professional football club setting. *J. Sports Sci.* 27, 1153–1158. doi: 10.1080/02640410903220328

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Olivier, J., and Bell, M. L. (2013). Effect sizes for 2x2 contingency tables. *PLoS One* 8:e58777. doi: 10.1371/journal.pone.0058777

Portugal Football Observatory (2021). Indicators. Available at: https://portugalfootballobservatory.fpf.pt/Indicator.aspx (Accessed March 8, 2021).

Romann, M., and Fuchslocher, J. (2011). Influence of the selection level, age, and playing position on relative age effects in Swiss women's soccer. *Talent Dev. Excell.* 3, 239–247.

Romann, M., Rüeger, E., Hintermann, M., Kern, R., and Faude, O. (2020). Origins of relative age effects in youth football—a nationwide analysis. *Front. Sports Act. Living* 2:591072. doi: 10.3389/fspor.2020.591072

Sedano, S., Vaeyens, R., and Redondo, J. C. (2015). The relative age effect in Spanish female soccer players. Influence of the competitive level and a playing position. *J. Hum. Kinet.* 46, 129–137. doi: 10.1515/hukin-2015-0041

Skorski, S., Skorski, S., Faude, O., Hammes, D., and Meyer, T. (2016). The relative age effect in German elite youth soccer: implications for a successful career. *Int. J. Sports Physiol. Perform.* 11, 370–376. doi: 10.1123/ijspp.2015-0071

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wattie, N., Schorer, J., and Baker, J. (2015). The relative age effect in sport: a developmental systems model. *Sports Med.* 45, 83–94. doi: 10.1007/s40279-014-0248-9

Williams, J. H. (2010). Relative age effect in youth soccer: analysis of the FIFA U17 world cup competition. *Scand. J. Med. Sci. Sports* 20, 502–508. doi: 10.1111/j.1600-0838.2009.00961.x

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The Relative Age Effect on Competition Performance of Spanish International Handball Players: A Longitudinal Study

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Background: Competitive success is the ultimate objective of elite professional sport organisations. Relative age effects (RAE) impact athlete selection processes in the short and long-term performance. The aims of this study were: (i) examine the presence of RAE by gender, competitive level, and playing position, as well as evaluate the impact of RAE on individual (goals, percentage of effectiveness in shots, saves; percentage of effectiveness in saves, assists, turnovers, steals, blocked shots, penalties, minutes played, and minutes played per match) and collective competition performance (final team position); and (ii) analyse the impact of RAE on the evolutionary trends of individual performance in international competitions throughout 16 seasons in Spanish handball (2005–2020).

Methods: The sample included 631 Spanish handball players (male: $n = 359$; female: $n = 272$). A Chi-square goodness-of-fit test was used to assess whether a skewed birthdate distribution occurred. A one-way analysis of variance (ANOVA) of independent measures was used to examine the individual and collective statistical parameters by birth quartiles. A linear regression in a Hopkins sheet were performed to compare individual performance trends.

Results: The results revealed RAE in the male formative categories ($p < 0.001$), as well as the male and female senior categories ($p < 0.05$). By position, RAE especially affected the "centre-back" in the male formative ($p < 0.01$) and senior categories ($p < 0.05$). No significant relationship between RAE and individual performance was found in male formative categories, while an impact of RAE on the "minutes played" was detected in the female senior category ($p < 0.05$). With regard to collective performance, a higher number of relatively older handball players was observed in the best ranked teams in the male formative categories and in the quarter-final teams in the female formative categories ($p < 0.05$). Among the male players, relatively older players spent more minutes on the court than relatively younger players, although this advantage dissipated over time and did not lead to better performance. Among the female players, relatively younger players were found to perform better as the level of competitive handball increased.

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Discussion: These findings are important for talent identification and development policies in sport federations and other elite sport institutions by demonstrating the many unintended consequences of selections to international competitions at the youth level.

Keywords: relative age effect, birthday effect, team sport, competition performance, talent identification, talent development, elite sport policy

INTRODUCTION

Developmental pathways are mapped by national sport federations to prepare young athletes for the demands of adult international competition (De Bosscher et al., 2006). In Spanish handball, the talent identification (TID) processes in national youth teams begin when female players are aged 16 years and male players are aged 17 years (although scouting and try-outs may occur earlier) (Bjørndal et al., 2018a). These youth development stages are organised into competition cycles for the duration of 2 years using a pre-established cut-off dates of January 1. Based on the timing of an athlete's birthdate within a given cohort, an individual can be relatively older or younger in comparison to his or her peers (Musch and Grondin, 2001). The biological and maturational differences among athletes born almost 12 months apart are actualized in physical, anthropometric, and physiological advantages, and could thus lead to a development disadvantage for some athletes; especially those born at the end of the selection year (Vaeyens et al., 2005). This is known as "relative age effects" (RAE), which can impact upon immediate, short-term, and long-term inequalities in the participation, selection, and attainment in handball (Barnsley et al., 1985).

RAE have been well-documented in team sports (Wattie et al., 2008), whereby an overrepresentation of relatively older athletes (e.g., those born in the first months of the selection year) compared to those who are relatively younger (e.g., those born in the latter months of the selection year) is a common theme in youth sport (Cobley et al., 2009). This phenomenon is particularly evident at higher levels of competition when athletes are selected into talent pathways (Baker et al., 2009). However, the impact of RAE may not necessarily be consistently strong throughout an athlete's development, whereby it often decreases as the chronological age of an athlete increases, and RAE may plateau as they reach adulthood (Brustio et al., 2018).

Variations in the impact of RAE on an athlete's career may also be affected by factors such as: (a) playing position (Fonseca et al., 2019; Pino-Ortega et al., 2020)—relatively older players tend to be overrepresented in the playing positions with higher physical and conditional demands (López-del-Río et al., 2019) or where certain key psychological characteristics such as leadership or self-confidence are needed (Chittle et al., 2017); (b) the role of coaches (Krahenbühl and Leonardo, 2020)—the positive perception of a player's performance in the formative stages can be decisive in order to be able to enjoy favourable competitive conditions and, thus, have a better chance of achieving high sport performance; (c) and/or individual characteristics (Camacho-Cardenosa et al., 2018)—the combined influence of the RAE with other variables, such as height or handedness, results, among other examples, in an overrepresentation of relatively older and taller basketball players or a high proportion of left-handed handball players born in the first months of the year at elite levels (Schorer et al., 2009; Rubajczyk et al., 2017).

RAE impact not only player selection, but the short-term and long-term competition performance of athletes (de la Rubia et al., 2020b; Kalén et al., 2020). As an example, short-term statistical parameters suggest that RAE can impact on individual performance, especially among young male players (Arrieta et al., 2016; Ibañez et al., 2018; de la Rubia et al., 2020a). Greater maturation development (i.e., see the "maturation-selection hypothesis" by Baker et al., 2010) in conjunction with unequal recruitment based on physical and anthropometric criteria, appears to lead to better sports performance among relatively older players (Jackson and Comber, 2020). However, in the context of international competitions for males, the impact seem less clear. International competitions are specialised high-performance sport contexts, and it might naturally be assumed that player selections would be influenced primarily by technical-tactical criteria (Karcher et al., 2014), a player's initial selection age, or the country's long-term performance (Kalén et al., 2020). The lack of impact of RAE on performance in female competitions has been explained by lower biological and conditional differences among players from the same selection year (Konstantinos et al., 2018) and by the "depth of competition hypothesis" (Baker et al., 2009). With regard to long-term competition performance, the trend seems to be varied or reversed (Kelly et al., 2021). Thus, relatively young players could achieve high performance, to a greater extent, if they manage to overcome the initial difficulties (McCarthy et al., 2016). This could be due, among other factors, to a higher development of specific technical-tactical skills (Güllich and Emrich, 2014), a lower injury rate (Bjørndal et al., 2018a), and relatively younger players having to grow from the adverse experiences of being initially disadvantaged (Collins and MacNamara, 2012).

RAE have been investigated using cross-sectional studies based on official statistics from specific competitions, such as the Handball World Championships. Individually, at the World Handball Championships held between 2013 and 2017, for example, de la Rubia et al. (2020a) showed that relatively older players (with the exception of the female senior category) played for more minutes than their relatively younger peers; although this does not necessarily results in better performance. However, Karcher et al. (2014) found that RAE had a limited impact on playing time, which varied primarily by playing position. Collectively, Saavedra and Saavedra (2020) identified an association between RAE and the final position of the female teams in the top eight places in the 2018 Women's Youth World Championship. A higher number of female players in these teams were also born in the first selection year compared to teams in lower positions. In contrast, however, Fonseca et al. (2019) did not detect any relationship between RAE and the final position of the teams in the male Youth World Handball Championship held in 2017. Nevertheless, there has also been a proliferation of longitudinal studies focusing on talent identification and development (TID) programmes designed by national sport federations. International competitions have been found to have a predominance of relatively older players. For instance, an overrepresentation of relatively older players on team season rosters was found in the German Handball Federation (DHB) between 1993 and 2007 (Schorer et al., 2013), in the Danish Handball Federation (DHF) between 2003 and 2017 (Wrang et al., 2018), and the Norwegian Handball Federation (NFH) between 2004 and 2017 (Bjørndal et al., 2018a).

RAE in team sports has been analysed using cross-sectional studies, cross-sectional studies of particular different ages in the same sport, and longitudinal studies (Dixon et al., 2020). To our knowledge, RAE in handball has not been evaluated using a combination of these three approaches together, using statistical performance parameters. Therefore, the broad aim of this study was to analyse the influence of RAE on the participation and performance of Spanish male and female handball players in official international competitions throughout 16 seasons (2005–2020). The specific aims were to use different methodological approaches to: (i) examine the prevalence of RAE at different competitive levels (formative and senior categories) and playing positions (i.e., goalkeeper, wing, centre-back, back, and pivot), and to evaluate the impact of RAE on individual and collective competition performances using official statistical parameters (a cross-sectional approach); and, (ii) analyse the long-term impacts of RAE using individual statistical parameters during the period 2005–2020 to observe possible technical-tactical performance trends (a longitudinal approach).

MATERIALS AND METHODS

Participants

The sample consisted of 631 handball players (male: n = 359; female: n = 272). All the players were selected by the Royal Spanish Handball Federation (RFEBM) to be part of the Spanish national teams which aimed to compete in the World Handball Championship organised by the International Handball Federation (IHF) during the 2005–2006 and 2019–2020 seasons. The competition categories we analysed corresponded to the official categories defined by the IHF for international tournaments, including: Female U-18 (n = 63), U-20 (n = 96), and senior (n = 113), as well as Male U-19 (n = 109), U-21 (n = 119), and senior (n = 131). For the subsequent analysis, the players were grouped in "formative categories" (U-18/U-19 and U-20/U-21) or the "senior category."

According to the biannual competition cycles established by the IHF (January 1 as a cut-off date), players categorised as "minors" (those who were selected despite being younger than the category selection year) were not included in the study sample in order not to duplicate data on date of birth in different variables (Steingröver et al., 2017). Thus, 3.8% of male players (U-19, n = 4; U-21, n = 10) and 0.4% of female players (U-18, n = 1) were excluded. Players in the formative categories (U-18/U-19 or U-20/U-21) could also be included later in the senior categories. Moreover, players were categorised by the playing position (goalkeeper: n = 85; wing: n = 160; back: n = 183; centre-back: n = 98; pivot: n = 105). Additionally, the birthdate distribution of the wider Spanish population between the ages of 15 and 40 years (i.e., the minimum and maximum age of the selected Spanish players) were extracted from the website of the National Institute of Statistics (INE) (https://www.ine.es/jaxi/Tabla.htm?path=/t20/e245/p08/l0/&file=01002.px) for comparison.

Procedures

Official player data were extracted from the "Competitions Archive" section of the IHF's official website (https://archive.ihf.info/en-us/ihfcompetitions/competitionsarchive.aspx) and verified by consulting the online library of the Royal Spanish Handball Federation (RFEBM) (https://www.rfebm.com/biblioteca). All the players' names were anonymised before analysis. No informed consent or ethical approval was required because the data were publicly accessible. The inclusion criteria for the selected seasons were to: (1) provide a reasonably wide sample of handball players (n = 631) from which to draw generalisable conclusions; (2) present a comprehensive database that could provide information about both handball players' profiles and competition performances (i.e., both individual and collective statistics); (3) analyse the only competition periods in which the World Handball Championships had taken place throughout the same biannual competition cycle in the three official competition categories (the Youth World Handball Championship competition was established in 2005 for males and in 2006 for females). We decided not include the European Youth Olympic Festival, the Youth Olympic Games, and the Olympic Games in the analysis because they did not meet any of these criteria.

Players were categorised in quartiles (Q), based on their birthdate and according to the competition cycles used by the IHF ("Fixtures and Results/Team Roster" section of the IHF website). In the formative categories, youth (U-18/U-19) and junior (U-20/U-21) players born in the first selection year (even years) of the biannual competition cycle were grouped as follows: between January 1 and March 31–Quartile 1 (Q1); between April 1 and June 30–Quartile 2 (Q2); between July 1 and September 30–Quartile 3 (Q3); between October 1 and December 31–Quartile 4 (Q4). Likewise, youth (U-18/U-19), and junior (U-20/U-21) players born in the second selection year (odd-numbered years) of the biannual competition cycle were grouped as follows: between January 1 and March 31–Quartile 5 (Q5); between April 1 and June 30–Quartile 6 (Q6); between July 1 and September 30–Quartile 7 (Q7); between October 1 and December 31–Quartile 8 (Q8). Only quartiles Q1–Q4 were applied when classifying senior players according to annual competition cycle. Additionally, the players were classified according to the playing position: "goalkeeper" (GK), "wing" (W), "back" (B), "centre-back" (CB), and "pivot" (P).

Individual and collective competition performance data were extracted from the "Fixtures and Results/Cumulative Statistics" section of the RFEBM website. The reliability of the data recording was checked by a second external observer handball coach with 5 years of experience. Thus, the observer was trained by means of an observation manual on the concordance agreement (Anguera, 1990) based on the kappa coefficient (Cohen, 1960). According to the kappa coefficient rating scale (Landis and Koch, 1977), all the recording variables presented indices equal to or >0.84 (almost perfect agreement), demonstrating the validity and reliability of the data recording and analysis process.: The statistical parameters and the Kappa coefficient associated with individual and collective competition performance were: (a) "goals" (Go; $\kappa = 0.95$); (b) "the percentage of effectiveness in shot" (PeSh; $\kappa = 0.92$); (c) "saves" (Sa; $\kappa = 0.90$); (d) "the percentage of effectiveness in saves" (PeSa; $\kappa = 0.88$); (e) "assists" (As; $\kappa = 0.87$); (f) "turnovers" (To; $\kappa = 0.86$); (g) "steals" (St; $\kappa = 0.94$); (h) "blocked shots" (BS; $\kappa = 0.91$); (i) "penalties" (Pen; $\kappa = 0.84$); (j) "time played" (Min; $\kappa = 0.90$); (k) "time played per match" (Min-M; $\kappa = 0.90$), and (l) "championship ranking" (Cl; $\kappa = 1.00$). The number of handball penalties was quantified as the sum of the number of yellow cards (x1) plus the number of exclusions (x2) plus the number of red/blue cards (x3). Collective performance was determined by the final team position at the end of each respective World Handball Championship.

Statistical Analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS 23.0, IBM Corp., Armonk, NY, USA). The differences between the observed and expected birthdate distributions (independent category) according to different dependent variables (gender, competition category, playing position and final team position) were tested using the chi-square goodness of fit test (χ^2), providing data with regard to absolute frequency (*n*), relative frequency (%) and degrees of freedom (*df*). By checking the homogeneous sample distribution of the Spanish population, the expected frequency of births in a quartile of 25% was established. Odds ratios (*OR*) were calculated for the quartile distributions to examine subgroup differences with respect to the potential non-uniformity of the birthdate distribution. The odds ratios compared the birthdate distribution of a particular quartile (Q1, Q2, Q3, Q4, Q5, Q6, or Q7) with the reference group of the relatively younger players (Q4/Q8). In order to determine the strength of association, a Cramer's V (*Vc*) was applied, in which 0.10–0.20 indicated a "weak association"; 0.20–0.40, a "moderate association"; 0.40–0.60, a "relatively strong association"; 0.60–0.80, a "strong association"; and, $Vc > 0.80$, a "very strong association" (Cohen, 1998). The level of significance was $p < 0.05$.

A one-way analysis of variance (*ANOVA*) of independent measures was used to examine the effects of RAE on the individual statistical parameters according to gender and competitive level. A Tukey *post-hoc* test was used to assess the differences within each group. Normality and homogeneity were verified through the Kolmogorov-Smirnov test (*K-S*) and the Levene test (homogeneous variances). Data were presented as the mean ± standard error ($X \pm SD$), statistical value (*F*), and effect size (η^2). The level of statistical significance was $p < 0.05$.

A linear regression was conducted to verify the impact of RAE (independent variable) on the individual performance (dependent variables) throughout the analysed period (2005–2020). Moreover, a Hopkins monitoring and reliability spreadsheet (Hopkins, 2017) was used to observe the qualitative inference of the independent variable (birthdate), expressing the data through the mean ± standard deviation ($X \pm SD$) and the slope of the linear regression ($y = m\,x + n$). Positive values of the slope mean an upward trend of the analysed statistical parameter, while negative values indicate a downward trend. The real possibilities of change in the performance variables were classified as follows: "<1%" = very unlikely increase/decrease; "1–5%" = unlikely trivial increase/decrease; "5–25%" = trivial increase/decrease "25–75%" = increase/decrease; "75–95%" = substantial increase/decrease; "95–99%" = likely substantial increase/decrease; and, ">99%" = very likely increase/decrease. The Hopkins' spreadsheet has been used in other studies of team sports to analyse variations in competition performance (Ward et al., 2018; Lorenzo et al., 2019) or physical performance (Pliauga et al., 2018; Ruf et al., 2018; Ferioli et al., 2020) over a period of time.

RESULTS

RAE—Gender, Competitive Level, and Playing Position

The quartile distribution of the birthdates, by competitive level, in each of the nine biannual cycles in the 2005–2020 seasons is shown in **Table 1**. A higher number of players born in the even-numbered years of the biannual competition cycle was observed in the formative categories ($n = 249$; 64.34%). The quartiles with the most representation of players in the formative categories were in the U-18/U-19 and U-20/U-21 categories: Q1 $n = 71$ (18.35%) and Q2 $n = 64$ (16.54%). In the senior category, the quartiles with the most representation of players were: Q1 $n = 80$ (32.79%) and Q4 $n = 63$ (25.82%).

Figures 1A,B present the quartile distribution and "*OR*" (Q1 to Q8/Q4) of the Spanish handball players by gender in the formative categories and the senior category of the national team throughout 16 seasons, respectively. RAE was evident in male formative categories [$\chi^2(7) = 38.60$, $p < 0.001$], as well as the male [$\chi^2(3) = 8.45$, $p < 0.05$] and female [$\chi^2(3) = 10.36$, $p < 0.05$] senior categories. The largest effect sizes were identified in the male formative categories, whilst a moderate association was evident between variables ($Vc = 0.41$). RAE were not found in the female formative categories ($p > 0.05$).

In the analysis of RAE on playing positions (**Table 2**), an overrepresentation of relatively older players (born in Q1) was found in the following cases: "goalkeeper" in male formative categories [$\chi^2(7) = 16.93$, $p < 0.05$]; "wing" in male formative [$\chi^2(7) = 19.19$, $p < 0.01$] and female senior categories [$\chi^2(3) = 11.25$, $p < 0.05$]; "centre-back" in male formative [$\chi^2(7) = 18.67$, $p < 0.01$] and senior categories [$\chi^2(3) = 9.67$, $p < 0.05$]. An overrepresentation of relatively younger players

TABLE 1 | Quarterly distribution ("*n*" and "%") of birthdates by competition level and biannual competition cycle.

BCC	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
	n(%)	*n(%)*	*n(%)*	*n(%)*	*n(%)*	*n(%)*	*n(%)*	*n(%)*
				Formative categories (U-18/U-19 and U-20/U-21)				
2005-06	4(13.3)	4(13.3)	5(16.7)	3(10.0)	7(23.3)	2(6.7)	4(13.3)	1(3.3)
2007-08	11(18.0)	13(21.3)	11(18.0)	10(16.4)	2(3.3)	6(9.8)	3(4.9)	5(8.2)
2009-10	18(29.5)	8(13.1)	7(11.5)	9(14.8)	3(4.9)	4(6.6)	3(4.9)	9(14.8)
2011-12	9(19.1)	3(6.4)	7(14.9)	10(21.3)	4(8.5)	7(14.9)	4(8.5)	3(6.4)
2013-14	8(26.7)	4(13.3)	5(16.7)	3(10.0)	4(13.3)	3(10.0)	2(6.7)	1(3.3)
2015-16	8(12.9)	12(19.4)	7(11.3)	6(9.7)	11(17.7)	6(9.7)	7(11.3)	5(8.1)
2017-18	8(12.7)	12(19.0)	11(17.5)	9(14.3)	6(9.5)	6(9.5)	6(9.5)	5(7.9)
2019-20	5(15.2)	8(24.2)	6(18.2)	5(15.2)	4(12.1)	0(0)	1(3.0)	4(12.1)
				Senior category				
2005-06	5(31.3)	5(31.3)	3(18.8)	3(18.8)	-	-	-	-
2007-08	13(40.6)	9(28.1)	6(18.8)	4(12.5)	-	-	-	-
2009-10	10(31.3)	9(28.1)	5(15.6)	8(25.0)	-	-	-	-
2011-12	9(28.1)	8(25.0)	6(18.8)	9(28.1)	-	-	-	-
2013-14	10(30.3)	9(27.3)	4(12.1)	10(30.3)	-	-	-	-
2015-16	12(37.5)	8(25.0)	3(9.4)	9(28.1)	-	-	-	-
2017-18	12(36.4)	4(12.1)	8(24.2)	9(27.3)	-	-	-	-
2019-20	9(26.5)	5(14.7)	9(26.5)	11(32.4)	-	-	-	-

"BCC," biannual competition cycle; "Q1-Q4/Q8," birth quarter.

(which runs contrary to the expected RAE) was detected among players in the "back" position in the male senior category [$\chi^2(3) = 17.06$, $p < 0.01$]. The greatest effect size was found in the "goalkeeper" position in the male formative categories ($Vc = 0.75$), and a strong association was identified. Equally strong effect sizes were found in the "centre-back" position in the male formative categories ($Vc = 0.72$), as well as the "centre-back" ($Vc = 0.63$) and "back" ($Vc = 0.72$) positions in the male senior category. RAE were not detected in any playing position in the female U-18/U-20 formative categories ($p > 0.05$).

RAE—Impact on Individual and Collective Performance

Table 3 shows the impact of RAE on individual performance by gender and competitive level throughout the period analysed (2005-2020). An impact of RAE on the "percentage of effectiveness in shots" ($p < 0.05$) was identified in the male formative categories, as well as on "turnovers" ($p < 0.01$), "steals" ($p < 0.01$), and "penalties" ($p < 0.01$) in the male senior category. In competitions for females, RAE affected the number of "steals" ($p < 0.01$), "penalties" ($p < 0.01$), "time played" ($p < 0.05$), and the "time played per match" ($p < 0.01$) in the senior category. *Post-hoc* analysis revealed that male U-19/U-21 players born in Q2 scored a higher "percentage of effectiveness in shots" than those born in Q3, whereas relatively younger players in the male senior category performed better in "steals." However, players born in Q4 registered more "turnovers" and "penalties." In the female senior category, relatively older players (born in Q1 and Q2) played a greater number of total minutes ("min") and per match ("min-m") than relatively younger players. In the U-18/U-20 female competitions, the impact of RAE on individual statistics was not detected ($p > 0.05$).

With regard to the relationship between RAE and collective performance (**Table 4**), an overrepresentation of relatively older players was detected in the semi-finalist teams [$\chi^2(7) = 17.57$, $p < 0.05$] and quarter-finalist teams [$\chi^2(7) = 25.07$, $p < 0.01$] in male formative categories (U-19/U-21) and the quarter-final teams [$\chi^2(7) = 21.67$, $p < 0.01$] in the female formative categories (U-18/U-20). The largest effect size was identified in the female formative categories, and a strong association was found between the variables ($Vc = 0.67$). RAE were found to have no impact in the teams ranked from the 9th to 24th place, both in the male and female formative categories, as well as in the senior teams ($p > 0.05$).

RAE—Performance Evolution Trends

In **Table 5**, we show the individual performance trends based on RAE (Q1 and Q4/Q8), by gender and competitive level, at the World Championships between 2005 and 2020. In the formative categories, no general trend over time in individual performance was detected during the 16 seasons ($p > 0.05$), except a downward trend in "goals" in relatively younger male players (14.43 ± 10.11, $y = -0.82$). In the senior categories, the impacts of RAE varied. Relatively older female players performed at a lower level in "assists" (6.41 ± 7.17, $y = -0.55$); while this negative performance trend was still evident in relatively older male players ("percentage of effectiveness in shots" $= 56.02 \pm 23.97$, $y = -2.20$; "percentage of effectiveness in saves" $= 33.00 \pm 3.67$, $y = -1.63$), "assists" (10.76 ± 10.45, $y = -0.57$),

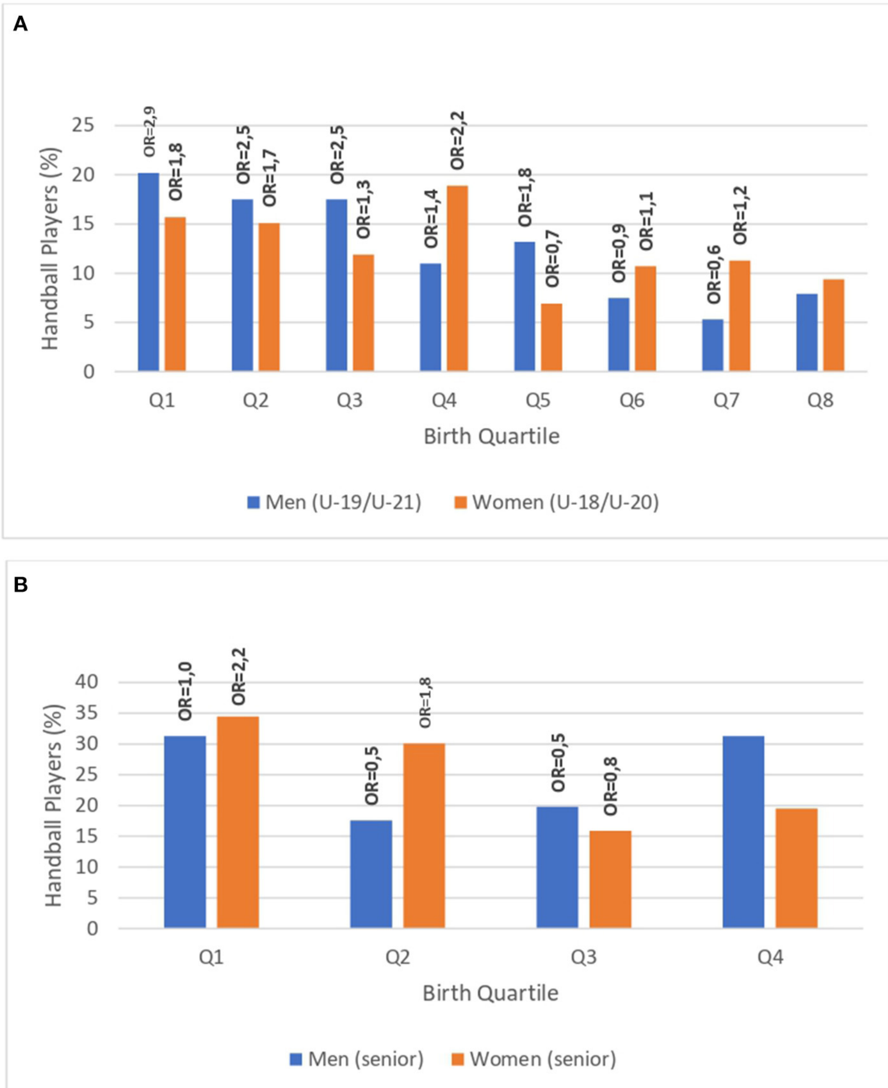

FIGURE 1 | (A) Quarterly distribution (% and OR) of birth dates by gender in formative categories. **(B)** Quarterly distribution (% and OR) of birth dates by gender in senior category.

and "penalties" (3.68 ± 4.12, $y = -0.28$). Nevertheless, the RAE affected relatively younger men differently than relatively younger women. The data revealed that men born in Q4 demonstrated a worse performance in skills such as "goals" (17.66 ± 10.26, $y = -1.02$), "assists" (9.85 ± 9.64, $y = -0.50$), and "minutes played" (236.98 ± 84.68, $y = -4.23$); while the trend was the opposite in women born at the end of the year (Q4) in "goals" (12.62 ± 11.47, $y = +1.16$); "percentage of effectiveness in shots" (59.14 ± 22.76, $y = +1.99$) and "assists" (7.23 ± 9.02, $y = +0.93$).

DISCUSSION

In the following section, we examine three key findings: (a) the prevalence of RAE and its impacts on performance; (b) the relationship between RAE and evolutionary trends (in 631 Spanish handball players) across the 2005–2020 handball seasons; and, (c) unanticipated finding including the presence of reverse RAE in the "back" players of the male senior category.

The Prevalence of RAE and Its Relation to Performance

The influence of RAE were observed in all the male player categories, but was only detected in the U-18 and senior categories in the female competitions. This lower incidence of RAE among female players could be explained by the "depth of competition hypothesis" (Baker et al., 2009), which suggests that RAE are likely to be less prevalent because there are fewer female players in competitive handball (Götze and Hoppe, 2021). In Spain, for example, only 36.04% of the 100,368 licences

TABLE 2 | Quarterly distribution (*n* and %) for playing position by gender and competitive level.

GEN	POS	Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		χ^2	*df*	*p*	*Vc*
		n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%				
M		**Formative categories (U-19/U-21)**																			
	GK	4	13.3	3	10.0	11	36.7	2	6.7	3	10.0	2	6.7	2	6.7	3	10.0	16.93	7	0.018	0.75
	W	6	11.1	15	27.8	8	14.8	6	11.1	10	18.5	5	9.3	2	3.7	2	3.7	19.19	7	0.008	0.60
	L	17	24.3	7	10.0	9	12.9	11	15.7	8	11.4	7	10.0	5	7.1	6	8.6	11.60	7	0.115	0.41
	CB	9	25.0	6	16.7	6	16.7	3	8.3	9	25.0	1	2.8	1	2.8	1	2.8	18.67	7	0.009	0.72
	P	10	26.3	9	23.7	6	15.8	3	7.9	0	0	2	5.3	2	5.3	6	15.8	11.74	6	0.068	0.56
		Senior category																			
	GK	5	27.8	10	55.6	0	0	3	16.7	-	-	-	-	-	-	-	-	4.33	2	0.115	0.49
	W	11	34.4	6	18.8	8	25.0	7	21.9	-	-	-	-	-	-	-	-	1.75	3	0.626	0.23
	L	8	24.2	3	9.1	4	12.1	18	54.5	-	-	-	-	-	-	-	-	17.06	3	0.001	0.72
	CB	11	45.8	4	16.7	8	33.3	1	4.2	-	-	-	-	-	-	-	-	9.67	3	0.022	0.63
	P	6	25.0	0	0	6	25.0	12	50.0	-	-	-	-	-	-	-	-	3.00	2	0.223	0.35
W		**Formative categories (U-18/U-20)**																			
	GK	9	40.9	0	0	2	9.1	4	18.2	3	13.6	1	4.5	0	0	3	13.6	10.73	5	0.057	0.70
	W	5	11.9	9	21.4	9	21.4	7	16.7	2	4.8	3	7.1	5	11.9	2	4.8	10.95	7	0.141	0.51
	L	4	8.2	9	18.4	5	10.2	9	18.4	3	6.1	9	18.4	4	8.2	6	12.2	7.33	7	0.396	0.39
	CB	5	20.8	2	8.3	3	12.5	6	25.0	2	8.3	2	8.3	3	12.5	1	4.2	6.67	7	0.464	0.53
	P	2	9.1	4	18.2	0	0	4	18.2	1	04.5	2	9.1	6	27.3	3	13.6	5.36	6	0.498	0.49
		Senior category																			
	GK	7	46.7	1	6.7	7	46.7	0	0	-	-	-	-	-	-	-	-	4.80	2	0.091	0.57
	W	11	34.4	14	43.8	2	6.3	5	15.6	-	-	-	-	-	-	-	-	11.25	3	0.010	0.59
	L	9	29.0	11	35.5	5	16.1	6	19.4	-	-	-	-	-	-	-	-	2.94	3	0.402	0.31
	CB	6	42.9	3	21.4	2	14.3	3	21.4	-	-	-	-	-	-	-	-	2.57	3	0.463	0.43
	P	6	28.6	5	23.8	2	9.5	8	38.1	-	-	-	-	-	-	-	-	3.57	3	0.312	0.41

"GEN," gender; "M," men; "W," women; "POS," playing position; "GK," goalkeeper; "W," wing; "LB," back; "CB," centre-back; "P," pivot; "Q1-Q4/Q8," birth quarter; "χ^2," Chi square; "df," degrees of freedom; "p," level of significance; "Vc," Cramer's V.

(for handball competitions) were issued for women (Consejo Superior de Deportes. Ministerio de Cultura y Deporte, 2019). Moreover, the official competitions organised by the RFEBM include more teams in categories for men ($n = 134$) than categories for women ($n = 70$). Furthermore, physical and anthropometric factors may influence the performance of male players more because of the physical requirements across playing positions in male handball (e.g., height and weight), which could explain the selection of relatively older players (Camacho-Cardenosa et al., 2018). These same attributes may not be as decisive in affecting players performance in the female categories (Konstantinos et al., 2018).

RAE decreased in the male competitions as the players aged over the seasons between 2005 and 2020, which has been noted in other studies (Wrang et al., 2018; Sá et al., 2020). However, our study revealed a trend was not detected in female categories, which suggests that RAE may vary more in female handball. Indeed, similar results have been reported by Schorer et al. (2009), whilst a reverse impact on RAE have been suggested by others, whereby relatively younger players are overrepresented in the senior categories as reported by Figueiredo et al. (2020). The physical demands throughout the different stages of sport development processes, as well as the level of competition and sociocultural factors, could explain the weak and moderate prevalence of RAE in female team sports, such as handball (Smith et al., 2018).

The influence of RAE on the selection processes for playing positions has been documented (Ibañez et al., 2018), with some researchers suggesting that the impact of RAE may be accentuated in handball because the sport requires a high degree of specialisation (Schorer et al., 2009). In our study, RAE affected most strongly the playing positions of "centre-back" in all male categories, as well as the "wing" in the male formatives and female senior categories. A similarly strong effect on the "wing" position has been also been reported in previous investigations of handball (Karcher et al., 2014; Figueiredo et al., 2020). Wing players are typically shorter, and because they are located in the outer areas of the court (Massuca et al., 2015), they cover the most distance and are the fastest players during match plays (Karcher and Buchheit, 2014). These performance requirements favour relatively older players being selected for this playing position because they require higher levels of physical performance, as demonstrated in tests such as the Yo-Yo Intermittent Recovery Test 1, the vertical jump height Abalakov, or the Barrow speed-agility test (Schwesig et al., 2017; Camacho-Cardenosa et al., 2018). The stronger prevalence of RAE for those playing in

TABLE 3 | Impact of the birth quartile (Q) on individual performance statistics (X ± SD) in Spanish handball players.

	Men									
	Formative Categories (U-19/U-21)					Senior Category				
Statistics	X ± SD	Q			Differences	X ± SD	Q			Differences
		F	p	η^2			F	p	η^2	
Go	14.69 ± 12.07	0.57	0.777	0.020	n.s.	17.54 ± 13.20	1.54	0.209	0.038	n.s.
PeSh	53.59 ± 24.87	2.40	<0.05	0.077	Q2 > Q3	54.92 ± 25.83	1.95	0.125	0.047	n.s.
Sa	47.90 ± 28.19	1.22	0.349	0.364	n.s.	52.89 ± 22.35	0.14	0.868	0.022	n.s.
PeSa	32.65 ± 6.59	0.72	0.660	0.251	n.s.	34.44 ± 3.42	1.57	0.245	0.195	n.s.
As	4.24 ± 5.15	0.65	0.712	0.022	n.s.	9.19 ± 9.32	2.23	0.089	0.054	n.s.
To	5.87 ± 5.25	1.35	0.227	0.045	n.s.	6.34 ± 5.59	4.11	<0.01	0.095	Q4 > Q2
St	0.57 ± 1.38	1.21	0.298	0.040	n.s.	3.60 ± 3.50	5.30	<0.01	0.119	Q4 > Q2; Q4 > Q3
BS	0.30 ± 1.75	0.61	0.751	0.021	n.s.	2.05 ± 3.79	1.02	0.388	0.025	n.s.
Pen	4.57 ± 4.81	0.79	0.594	0.027	n.s.	4.73 ± 5.09	4.27	<0.01	0.098	Q4 > Q1
Min	207.92 ± 97.78	0.93	0.486	0.031	n.s.	234.56 ± 84.91	0.42	0.738	0.011	n.s.
Min-M	25.09 ± 11.29	0.98	0.446	0.033	n.s.	25.71 ± 8.79	0.19	0.905	0.005	n.s.
	Women									
	Formative Categories (U-18/U-20)					Senior Category				
Statistics	X ± SD	Q			Differences	X ± SD	Q			Differences
		F	p	η^2			F	p	η^2	
Go	12.29 ± 11.54	0.38	0.912	0.020	n.s.	13.38 ± 12.66	2.14	0.100	0.062	n.s.
PeSh	49.20 ± 24.71	1.97	0.064	0.093	n.s.	53.80 ± 26.22	0.70	0.558	0.021	n.s.
Sa	35.27 ± 20.90	2.69	0.079	0.551	n.s.	47.47 ± 26.90	0.21	0.815	0.040	n.s.
PeSa	30.06 ± 8.51	1.05	0.436	0.324	n.s.	35.40 ± 5.73	0.52	0.610	0.094	n.s.
As	3.35 ± 4.62	0.75	0.633	0.038	n.s.	6.73 ± 7.63	0.91	0.438	0.027	n.s.
To	7.68 ± 7.03	0.57	0.776	0.029	n.s.	7.45 ± 7.96	0.59	0.622	0.018	n.s.
St	1.10 ± 2.57	1.38	0.219	0.067	n.s.	2.32 ± 2.85	4.08	<0.01	0.112	Q2 > Q3
BS	0.34 ± 1.62	0.92	0.495	0.046	n.s.	1.27 ± 2.63	1.40	0.247	0.042	n.s.
Pen	4.36 ± 4.45	1.08	0.381	0.053	n.s.	4.91 ± 4.96	5.67	<0.01	0.149	Q2 > Q3; Q2 > Q4
Min	183.79 ± 94.74	0.55	0.798	0.028	n.s.	204.43 ± 104.64	3.17	<0.05	0.089	Q1 > Q3; Q2 > Q3
Min-M	26.29 ± 12.62	0.79	0.595	0.040	n.s.	26.02 ± 11.30	4.52	<0.01	0.123	Q1 > Q3; Q2 > Q3

"U-19/U-21," male youth and junior categories; "U-18/U-20," female youth and junior categories; "Go," goals; "PeSh," percentage of effectiveness in shots; "Sa," saves; "PeSa," percentage of effectiveness in saves; "As," assists; "To," turnovers; "St," steals; "BS," blocked Shots; "Pen," Penalties; "Min," minutes played; "Min-M," minutes played per match; "Cl," classification; "Q1-Q4/Q8," birth quartile; "F," statistic (ANOVA); "p," level of significance; "η^2," eta squared statistic (effect size); "n.s.," not significant.

"centre-back" positions could be explained, not only by the specific physical characteristics and sport demands required, but also by the favourable psychological characteristics of relatively older players, such as self-confidence and leadership, that could help to enhance players' performances (Chittle et al., 2017). Furthermore, from an environmental perspective, coaches may be more likely to choose older players for these positions (Krahenbühl and Leonardo, 2020).

RAE were found not to have a significant impact on the individual performance parameters of players in the formative categories (U-18/U-19 and U-20/U-21). Although RAE generally affected the selection processes in these stages, the potential for successful performance did not decrease based on the relative age of the athletes (García et al., 2014; Rubajczyk et al., 2017). In international competitions, coaches tend to align players according to technical-tactical criteria (Karcher et al., 2014), depending on the specificity of particular playing positions (Ibañez et al., 2018). In the initial selection process, strict player screening according to specific physical sport criteria (Schorer et al., 2013) could mean that individual performance is not excessively affected by RAE (Bjørndal et al., 2018a). On the other hand, studies have demonstrated a relationship between RAE and individual competition performance in the lower competition categories of handball (de la Rubia et al., 2020a; Krahenbühl and Leonardo, 2020). Nevertheless, the parameter considered was "played time" and, therefore, the impact of RAE on other statistical performance might not have been apparent or appreciated. Interestingly, in the male senior category, relatively younger players (Q4) were found to make more mistakes than those born in Q2 and Q1, whilst in the female senior category,

TABLE 4 | Quarterly distribution (*n* and %) of birth dates by gender and competitive level according to the final team position.

Formative categories						
Q	**Men (U-19/U-21)**			**Women (U-18/U-20)**		
	Semi-finalists	**Quarter-finalists**	**Bottom sixteen**	**Semi-finalists**	**Quarter-finalists**	**Bottom sixteen**
Q1	15(16.3)	29(24.2)	2(12.5)	2(12.5)	14(29.2)	9(9.5)
Q2	16(17.4)	20(16.7)	4(25.0)	4(25.0)	10(20.8)	10(10.5)
Q3	18(19.6)	20(16.7)	2(12.5)	2(12.5)	5(10.4)	12(12.6)
Q4	10(10.9)	11(9.2)	4(25.0)	4(25.0)	8(16.7)	18(18.9)
Q5	16(17.4)	11(9.2)	3(18.8)	1(6.3)	2(4.2)	8(8.4)
Q6	7(7.6)	10(8.3)	0(0)	1(6.3)	2(4.2)	14(14.7)
Q7	5(5.4)	7(5.8)	0(0)	1(6.3)	4(8.3)	13(13.7)
Q8	5(5.4)	12(10.0)	1(6.3)	1(6.3)	3(6.3)	11(11.6)
χ^2	17.57	25.07	2.75	6.00	21.67	5.97
df	7	7	5	7	7	7
p	0.014	0.001	0.738	0.540	0.003	0.543
Vc	0.44	0.46	0.41	0.61	0.67	0.25
Senior category						
Q	**Men**			**Women**		
	Semi-finalists	**Quarter-finalists**	**Bottom sixteen**	**Semi-finalists**	**Quarter-finalists**	**Bottom sixteen**
Q1	21(32.8)	17(33.3)	3(18.8)	17(35.4)	0(0)	22(33.8)
Q2	13(20.3)	5(9.8)	5(31.3)	13(27.1)	0(0)	21(32.3)
Q3	9(14.1)	14(27.5)	3(18.8)	8(16.7)	0(0)	10(15.4)
Q4	21(32.8)	15(29.4)	5(31.3)	10(20.8)	0(0)	12(18.5)
χ^2	6.75	6.65	1.00	3.83	-	6.94
df	3	3	3	3	-	3
p	0.080	0.084	0.801	0.280	-	0.074
Vc	0.32	0.36	0.25	0.28	-	0.33

"U-19/U-21," male youth and junior categories; "U-18/U-20," female youth and junior categories; "Q1-Q4/Q8," birth quartile; "X^2," Chi square; "df," degrees of freedom; "p," level of significance; "Vc," Cramer's V.

the relatively older players (Q1 and Q2) enjoyed more time on the court than those born in Q3.

Some studies have reported a lower incidence of RAE in the senior category (Cobley et al., 2009; Smith et al., 2018; de la Rubia et al., 2020b). However, in team sports, RAE has been found to also affect competition performance in adult stages (Vaeyens et al., 2005). If coaches focus on immediate results or short-term objectives, they are more likely to favour relatively older players, especially in the formative categories. In Spanish handball, due to its great popularity, this fact could also be explained by secondary environmental factors, such as better training conditions, coaching resources and higher competitive levels (Hancock et al., 2013). This reality fosters the creation of self-strengthening mechanisms in relatively older players who would tend to achieve high performance in a higher proportion than relatively younger players (Barnsley et al., 1992). This is what is known as "The Matthew Effect" (Nolan and Howell, 2010) and highlights how the "when" and "where" could have an impact on performance.

In the analysis of collective competition performance, RAE were found to influence the final team positions in the formative categories of handball (González-Víllora et al., 2015; Arrieta et al., 2016; Rubajczyk et al., 2017). Similar studies have showed a strong correlation between result rankings in youth and senior categories in international competitions (Bjørndal et al., 2018b), which suggests that addressing unequal opportunities in initial player selections is particularly important. From a talent development perspective, this means that during their sporting careers, relatively younger players are able gradually to overcome differences caused by their initial lag in relative age by acquiring technical-tactical, strategic and psychological skills (McCarthy and Collins, 2014). Consequently, by the time they reach the senior category, physical-anthropometric factors become once again equal across the birthdates, and relatively older players no longer have any special advantage over younger players (Bjørndal et al., 2018a). Surprisingly, some studies have reported a reverse RAE, in which relatively younger players are overrepresented in senior categories (Gibbs et al., 2012; Fumarco et al., 2017; de la Rubia et al., 2020b). This, as some have

TABLE 5 | Pairwise comparisons between relatively older (Q1) and relatively younger (Q4/Q8) handball players of the individual performance throughout the last 16 seasons (2005–2020) according to gender and competition level.

I.P.S	Men															
	Formative categories (U-19/U-21)								Senior category							
	Q1				Q2				Q3				Q4			
	X ± SD	*p*	Slope	QI	X ± SD	*p*	Slope	QI	X ± SD	*p*	Slope	QI	X ± SD	*p*	Slope	QI
Go	17.71 ± 10.87	0.913	0.19	?	14.43 ± 10.11	0.029	−0.82	↓	18.49 ± 11.58	0.253	−0.22	?	17.76 ± 10.26	0.004	−1.02	↓*
PeSh	52.06 ± 24.55	0.415	1.15	?	43.86 ± 31.78	0.504	−2.00	?	56.02 ± 23.97	0.009	−2.20	↓*	59.24 ± 24.21	0.744	−0.23	?
Sa	20.25 ± 9.81	0.610	−0.10	?	34.67 ± 17.62	0.247	0.93	?	55.80 ± 27.38	0.021	5.02	↑*	51.67 ± 35.57	0.856	0.40	?
PeSa	33.00 ± 8.04	0.824	0.71	?	34.33 ± 6.35	0.181	1.97	?	33.00 ± 3.67	0.006	−1.63	↓*	36.33 ± 3.06	0.538	0.42	?
As	5.13 ± 5.49	0.727	0.12	?	2.94 ± 4.33	0.118	−0.14	?	10.76 ± 10.45	0.043	−0.57	↓*	9.85 ± 9.64	0.286	−0.50	↓*
Pen	4.85 ± 5.28	0.114	−0.09	?	5.61 ± 6.34	0.144	0.26	?	3.68 ± 4.12	0.045	−0.28	↔↓	7.17 ± 6.21	0.315	−0.18	?
Min	194.24 ± 83.77	0.187	5.24	?	191.90 ± 90.71	0.425	−4.39	?	233.95 ± 83.44	0.745	−1.12	?	236.98 ± 84.68	0.047	−4.23	↓*
Min-M	23.67 ± 10.27	0.686	0.37	?	22.78 ± 10.34	0.189	−0.84	?	25.85 ± 9.10	0.315	0.24	?	26.18 ± 8.82	0.532	−0.07	?
	Women															
I.P.S	**Formative categories (U-18/U-20)**								**Senior category**							
	Q1				**Q2**				**Q3**				**Q4**			
	X ± SD	***p***	**Slope**	**QI**	**X ± SD**	***p***	**Slope**	**QI**	**X ± SD**	***p***	**Slope**	**QI**	**X ± SD**	***p***	**Slope**	**QI**
Go	14.12 ± 14.08	0.699	−0.78	?	14.36 ± 13.62	0.934	0	?	14.88 ± 10.23	0.116	0.10	?	12.62 ± 11.47	0.042	1.16	↑*
PeSh	40.87 ± 32.23	0.306	−0.15	?	41.50 ± 27.40	0.707	−0.79	?	54.51 ± 26.77	0.794	0.42	?	59.14 ± 22.76	0.049	1.99	↑*
Sa	41.56 ± 21.21	0.406	0.31	?	49.67 ± 1.53	0.471	0.21	?	59.43 ± 30.52	0.793	0.64	?	0 ± 0	-	-	-
PeSa	32.20 ± 5.24	0.230	−1.51	?	34.90 ± 1.25	0.477	0.16	?	36.86 ± 5.73	0.741	0.40	?	0 ± 0	-	-	-
As	2.60 ± 2.86	0.951	0.02	?	2.40 ± 2.97	0.882	−0.17	?	6.41 ± 7.17	0.049	−0.55	↓*	7.23 ± 9.02	0.036	0.93	↑*
Pen	3.84 ± 5.47	0.801	0.06	?	3.53 ± 4.34	0.846	0.02	?	5.05 ± 5.43	0.174	0.01	?	3.95 ± 3.47	0.333	0.14	?
Min	180.99 ± 104.26	0.100	−7.83	?	155.57 ± 82.47	0.901	5.10	?	228.45 ± 105.66	0.673	−1.30	?	164.35 ± 71.03	0.339	1.17	?
Min-M	25.25 ± 13.97	0.103	−0.99	?	20.97 ± 10.93	0.569	0.90	?	28.69 ± 10.78	0.741	0.13	?	21.61 ± 8.11	0.187	0.32	?

"U-19/U-21," male youth and junior categories; "U-18/U-20," female youth and junior categories; "Q1," relative older players; "Q4/Q8," relative younger players; "p," significance level; "QI," qualitative inference; "I.P.S.," individual performance statistics; "Go," goals; "PeSh," percentage of effectiveness in shots; "Sa," saves; "PeSa," percentage of effectiveness in saves; "As," assists; "Pen," penalties; "Min," minutes played; "Min-M," minutes played per match; "?," very unlikely increase/decrease (unclear change); "↔↑/↔↓*," unlikely trivial increase/decrease; "↔↑/↔↓," trivial increase/decrease; "↑/↓," substantial increase/decrease; "↑*/↓*," likely substantial increase/decrease; "-," No statistical data for this subgroup of the sample.*

argued, could be explained based on the psychological influence of the additional challenges experienced by the relatively younger players through their developmental journey (McCarthy et al., 2016). For example, Collins et al. (2016) have argued that talented potential can often benefit from, or even need, a variety of challenges to facilitate eventual adult performance, whereby being a later maturer could pose as one such challenge. However, as with the other proposed explanations for the impacts of the RAE in sport, they claim should be treated with caution until it has been substantiated by more empirical evidence.

The Relationship Between RAE and Evolutionary Trends

Our results are congruent with other studies of the impact of the RAE in national talent development programmes in handball in two key ways: (1) RAE appeared to decrease progressively throughout the developmental stages (see also Bjørndal et al., 2018a; Figueiredo et al., 2020; Sá et al., 2020); and, (2) the presence of relatively younger players was found to increase as the age of the players increased over the seasons (see also Wrang et al., 2018). However, as noted earlier, our analysis extended beyond the approaches that have been used in previous research because it also investigated the potential impacts of the RAE across *long-term* player performance. Specifically, our study revealed no performance trends affected by the RAE in the formative categories throughout the 16 seasons analysed, except a downward trend observed in "goals" in relatively young male players, while in the senior category the trends are different by gender: in men, a worsening of performance was identified in both the relatively older and the younger players; and, in women, the trend did not vary for relatively older women, but a better performance was observed in relatively younger women.

In men's competitions, the RAE was not the main factor affecting long-term individual performance. The lack of the RAE in male players within the RFEBM TID system (Gómez-López et al., 2017; Camacho-Cardenosa et al., 2018) seems to indicate that the selection processes are organised around criteria that are far from the physical and maturational component.

Therefore, a recruitment methodology based on game-specific factors and technical-tactical skills could mean that all players start with the same opportunities to compete in specialised international contexts (Karcher et al., 2014). Furthermore, a training of coaches oriented to the promotion of these strategies, as advocated Krahenbühl and Leonardo (2020), would move the selection processes away from the immediate and current performance of the player (Bailey and Collins, 2013), favouring competition performance not biassed by the RAE. Indeed, Bjørndal et al. (2018a) showed that, although international team selections favour relatively older players, they do not strongly affect the possibility of achieving a long-term individual performance internationally.

At the higher competitive levels (i.e., senior category), those female players who achieved the best performance were relatively younger. Therefore, RAE did not appear to limit the selections or performance of female players over time. Among other factors (e.g., depth of competition and reduced pool of players), this trend could be explained by the relatively earlier start of pubertal maturation compared to males. The fastest growth rate in females occurs between the ages of 11 and 14 years (Malina et al., 2015), and the maturity status tends to equalise earlier than males. This means that there are likely to be almost no differences in the physical maturity of the female players at higher competitive levels (Smith et al., 2018), as well as that relatively younger female handball players could potentially achieve better sport performance earlier than their male counterparts. This positive evolution in relatively younger female players would highlight the "underdog effect" with regard to competition performance (Fumarco et al., 2017). The female players born at the end of the year would overcome physical and maturational differences and benefit, over time, from an acquisition of technical-tactical and psychological skills superior to those acquired by relatively older players (McCarthy et al., 2016).

Unanticipated Finding

Surprisingly, reverse RAE were detected among players in the "back" position in the male handball senior category, whereby relatively younger players were favoured over relatively older counterparts. This position requires strong and tall players (Karcher and Buchheit, 2014) and is even affected by the concept of "handedness," especially on the right side of the court (Schorer et al., 2009). However, a possible explanation could be based on environmental factors. The relatively younger players in this instance may have benefited from favourable training conditions in the specific context of the Spanish handball game setting—a model which focuses strongly on individual techniques and tactical training rather than physical qualities alone (Román Seco, 2008). The development of technical-tactical skills may have helped to alleviate differences between them and their more mature peers. Therefore, the placement in this position of players with superior visual perception skills, linked to the offensive collective game standards of Spanish handball, may result in a lower component of specialisation players in the "back" position (Román Seco, 2009). Further, if the versatility of this kind of player is considered, it could result in relatively younger players being selected for the "back" position, unlike for other positions. Future research should aim to analyse whether those players who play the "back" position in the senior category are, perhaps, late maturers who require a longer period to develop physically.

Limitations

First, a relatively small sample size, in terms of the birthdate distribution (Q), has meant that some statistical analyses could not be carried out due to a low frequency (<5), especially with the stratification of the sample by gender, category and playing position. Second, the individual performances of players could not be accurately compared due to the lack of a general performance indicator, such as a "performance index rating—PIR" (Rubajczyk et al., 2017; Ibañez et al., 2018) that would have allowed us to analyse the impact of RAE more objectively. Third, the lack of individual performance data from other international competitions (European Handball Championships or Olympic Games) meant it was not possible to examine or compare the relationship between RAE and performance in, or across, other contexts. Fourth, the study considered only the internal context of national teams and the associated performance of the players involved. This meant that we were not able to compare other prior selection processes in other environments (such as clubs, regional teams, and follow-up talent concentrations). Fifth, some of the Spanish national teams did not compete in the World Handball Championships (i.e., 2005–2006: male U-19 and female U-18; 2011–2012: female U-18; and, 2013–2014: female U-18 and female U-20). The 2019–2020 cycle was also interrupted by the suspension of official handball competitions due to by COVID-19, thus the female U-18 and female U-20 teams did not compete.

CONCLUSIONS

The present study was designed to address the absence of longitudinal studies by exploring the relationship between RAE and competition performance, as well as providing an overview of how the relationship has evolved over time. This is an especially important focus in team sports, such as handball, where performance is multifactorial and difficult to assess. Our findings showed that RAE were a determining factor in the player selection processes conducted by the RFEBM Spanish handball teams for the World Handball Championships held between 2005 and 2020. Although some variability of the prevalence of RAE were observed by gender, competitive level, and playing position, RAE proved to be a critical factor shaping the processes of talent identification and development programmes in this elite professional sport organisation.

However, it was not clear from the data if RAE had an impact on the individual and collective performance of players according to the variables analysed. In the formative categories, a high percentage of relatively older players appeared to favour better ranking success. In the senior category, RAE affected those born in the first months of the year only in terms of a higher number of minutes played. Differences in individual performance between the relatively younger Spanish handball players and the relatively older players gradually lessened through the eight biannual cycles we analysed, except in the female competitive categories. Greater variability in the impact of RAE, as well as sociocultural and sport-specific factors associated with handball competitions, could be responsible for our failure to identify a clear RAE-linked long-term performance trend in Spanish female handball.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

REFERENCES

Anguera, M. T. (1990). Metodología observacional. *Res. Methodol. Behav. Sci.* 1, 125–236.

Arrieta, H., Torres-Unda, J., Gil, S. M., and Irazusta, J. (2016). Relative age effect and performance in the U16, U18 and U20 european basketball championships. *J. Sports Sci.* 34, 1530–1534. doi: 10.1080/02640414.2015.1122204

Bailey, R., and Collins, D. (2013). The standard model of talent development and its discontents. *Kinesiol. Rev.* 2, 248–259. doi: 10.1123/krj.2.4.248

Baker, J., Cobley, S. P., and Winckel, V. (2009). Gender, depth of competition, and relative age effects in team sports. *Asian J. Exerc. Sports Sci.* 6, 1–8.

Baker, J., Schorer, J., and Cobley, S. (2010). Relative age effects. An inevitable consequence of elite sport? *Sportwiss* 40, 26–30. doi: 10.1007/s12662-009-0095-2

Barnsley, R., Thompson, A., and Barnsley, P. (1985). Hockey success and birthdate: the relative age effect. *J. Can. Assoc. Health Phys. Educ. Recreat.* 51, 23–28.

Barnsley, R. H., Thompson, A. H., and Legault, P. (1992). Family planning: football style. The relative age effect in football. *Int. Rev. Sociol. Sport* 27, 77–87. doi: 10.1177/101269029202700105

Bjørndal, C. T., Luteberget, L., Till, K., and Holm, S. (2018a). The relative age effect in selection to international team matches in Norwegian handball. *PLoS ONE* 13:e0209288. doi: 10.1371/journal.pone.0209288

Bjørndal, C. T., Luteberget, L. S., and Holm, S. (2018b). The relationship between early and senior level participation in international women's and men's handball. *J. Hum. Kinet.* 63, 73–84. doi: 10.2478/hukin-2018-0008

Brustio, P. R., Lupo, C., Ungureanu, A. N., Frati, R., Rainoldi, A., and Boccia, G. (2018). The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. *PLoS ONE* 13:e0196253. doi: 10.1371/journal.pone.0196253

Camacho-Cardenosa, A., Camacho-Cardenosa, M., González-Custodio, A., Martínez-Guardado, I., Timón, R., Olcina, G., et al. (2018). Anthropometric and physical performance of youth handball players: the role of the relative age. *Sports* 6, 1–10. doi: 10.3390/sports6020047

Chittle, L., Horton, S., Weir, P., and Dixon, J. C. (2017). Investigating the relationship between the relative age effect and leadership behaviors among male ice hockey players. *Int. Rev. Sociol. Sport* 52, 751–768. doi: 10.1177/1012690215616271

Cobley, S. P., Baker, J., Wattie, N., and McKenna, J. (2009). Annual age-grouping and athlete development. A meta-analytical review of relative age effects in sport. *Sports Med.* 39, 235–256. doi: 10.2165/00007256-200939030-00005

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educ. Psychol. Meas.* 20, 37–46. doi: 10.1177/001316446002000104

Cohen, J. (1998). *Statistical Power Analysis for the Behavioral Sciences, 2nd Edn*. New York, NY: Routledge.

Collins, D., and MacNamara, A. (2012). The rocky road to the top. Why talent needs trauma. *Sports Med.* 42, 907–914. doi: 10.1007/BF03262302

Collins, D., MacNamara, A., and McCarthy, N. (2016). Super champions, champions, and almosts: important differences and commonalities on the rocky road. *Front. Psychol.* 6:2009. doi: 10.3389/fpsyg.2015.02009

Consejo Superior de Deportes. Ministerio de Cultura y Deporte (2019). *Estadística de deporte federado*. Available online at: http://www.culturaydeporte.gob.es/dam/jcr:6b7e9a1a-e3e5-4b45-8ae5-6f187b50235f/nota-resumen-estadistica-deporte-federado-2018.pdf (accessed February 8, 2021).

De Bosscher, V., De Knop, P., Van Bottenburg, M., and Shibli, S. (2006). A conceptual framework for analysing sports policy factors leading to international sporting success. *Eur. Sport Manag. Q.* 6, 185–215. doi: 10.1080/16184740600955087

de la Rubia, A., Bjørndal, C. T., Sánchez-Molina, J., Yagüe, J. M., Lorenzo, J., and Maroto-Izquierdo, S. (2020a). The relationship between the relative age effect and performance among athletes in World Handball Championships. *PLoS ONE* 15:e0230133. doi: 10.1371/journal.pone.0230133

de la Rubia, A., Lorenzo-Calvo, J., and Lorenzo, A. (2020b). Does the relative age effect influence short-term performance and sport career in team sports? a qualitative systematic review. *Front. Psychol.* 11:1947. doi: 10.3389/fpsyg.2020.01947

Dixon, J. C., Horton, S., Chittle, L., and Baker, J. (2020). *Relative Age Effects in Sport. International Perspectives*. New York, NY: Routledge.

Ferioli, D., Bosio, A., Zois, J., La Torre, A., and Rampinini, E. (2020). Seasonal changes in physical capacities of basketball players according to competitive levels and individual responses. *PLoS ONE* 15:e0230558. doi: 10.1371/journal.pone.0230558

Figueiredo, L. S., Gantois, P., de Lima-Junior, D., de Sousa Fortes, L., and de Souza Fonseca, F. (2020). The relationship between relative age effects and sex, age categories, and playing positions in Brazilian National Handball Teams. *Driving Phys. Educ. Mag.* 26, 1–8. doi: 10.1590/s1980-6574202000040045

Fonseca, F. S., Figueiredo, L. S., Gantois, P., de Lima-Junior, D., and Fortes, L. S. (2019). Relative age effect is modulated by playing position but is not related to competitive success in elite under-19 handball athletes. *Sports* 7, 1–10. doi: 10.3390/sports7040091

Fumarco, L., Gibbs, B. G., Jarvis, J. A., and Rossi, G. (2017). The relative age effect reversal among the National Hockey League elite. *PLoS ONE* 12:e0182827. doi: 10.1371/journal.pone.0182827

García, M. S., Aguilar, Ó. G., Romero, J. J. F., Lastra, D. F., and Oliveira, G. E. (2014). Relative age effect in lower categories of international basketball. *Int. Rev. Sociol. Sport* 49, 526–535. doi: 10.1177/1012690212462832

Gibbs, B. G., Jarvis, J. A., and Dufur, M. J. (2012). The rise of the underdog? the relative age effect reversal among Canadian-born NHL hockey players: a reply to Nolan and Howell. *Int. Rev. Sociol. Sport* 47, 644–649. doi: 10.1177/1012690211414343

Gómez-López, M., Sánchez, S. A., Sánchez, V. R., and Pérez Turpín, J. A. (2017). Relative age effect in handball players of Spain. *J. Phys. Educ. Sport* 17, 705–711. doi: 10.7752/jpes.2017.02106

González-Víllora, S., Pastor-Vicedo, J. C., and Cordente, D. (2015). Relative age effect in UEFA championship soccer players. *J. Hum. Kinet.* 47, 237–248. doi: 10.1515/hukin-2015-0079

Götze, M., and Hoppe, M. W. (2021). Relative age effect in elite german soccer: influence of gender and competition level. *Front. Psychol.* 11:587023. doi: 10.3389/fpsyg.2020.587023

Güllich, A., and Emrich, E. (2014). Considering long-term sustainability in the development of world class success. *Eur. J. Sport Sci.* 14, 37–41. doi: 10.1080/17461391.2012.706320

Hancock, D. J., Adler, A. L., and Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *Eur. J. Sport Sci.* 13, 630–637. doi: 10.1080/17461391.2013.775352

Hopkins, W. G. (2017). A spreadsheet for monitoring an individual's changes and trend. *Sport Sci.* 21, 5–9.

Ibañez, S. J., Mazo, A., Nascimento, J., and Garcia-Rubio, J. (2018). The relative age effect in under-18 basketball: effects on performance according to playing position. *PLoS ONE* 13:e0200408. doi: 10.1371/journal.pone.0200408

Jackson, R. C., and Comber, G. (2020). Hill on a mountaintop: a longitudinal and cross-sectional analysis of the relative age effect in competitive youth football. *J. Sports Sci.* 38, 1352–1358. doi: 10.1080/02640414.2019.1706830

Kalén, A., Lundkvist, E., Ivarsson, A., Rey, E., and Pérez-Ferreirós, A. (2020). The influence of initial selection age, relative age effect, and country long-term performance on the re-selection process in European basketball youth national teams teams. *J. Sports Sci.* 39, 388–394. doi: 10.1080/02640414.2020.1823109

Karcher, C., Ahmaidi, S., and Buchheit, M. (2014). Effect of birth date on playing time during international handball competitions with respect to playing positions. *Kinesiology* 46, 23–32.

Karcher, C., and Buchheit, M. (2014). On-Court demands of elite handball, with special reference to playing positions. *Sports Med.* 44, 797–814. doi: 10.1007/s40279-014-0164-z

Kelly, A. L., Till, K., Jackson, D. T., Barrell, D., Burke, K., and Turnnidge, J. (2021). Talent identification and relative age effects in English male rugby union pathways: From entry to expertise. *Frontiers in Sports and Active Living* 3, 1–9. doi: 10.3389/fspor.2021.640607

Konstantinos, N. S., Elissavet, R. N., Panagiotis, G. M., Ioannis, B. A., and Konstantinos, B. D. (2018). Performance indicators and competition ranking in women's and men's world. *J. Phys. Educ. Sport* 18, 1761–1766. doi: 10.7752/jpes.2018.03256

Krahenbühl, T., and Leonardo, L. (2020). The relative age effect: coaches' choices as evidence of social influence on youth handball. *J. Phys. Educ. Sport* 20, 2460–2467. doi: 10.7752/jpes.2020.05337

Landis, J. R., and Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics* 33, 159–174. doi: 10.2307/2529310

López-del-Río, M., Rabadán, D., Redondo, J. C., and Sedano, S. (2019). Relative age effect in professional football: influence of competitive level and playing position. *Apunts Phys. Educ. Sports* 138, 26–39. doi: 10.5672/apunts.2014-0983.es.(2019/4)0.138.02

Lorenzo, J., Lorenzo, A., Conte, D., and Giménez, M. (2019). Long-term analysis of elite basketball players' game-related statistics throughout their careers. *Front. Psychol.* 10:421. doi: 10.3389/fpsyg.2019.00421

Malina, R. M., Rogol, A. D., Cumming, S. P., Coelho-e-Silva, M. J., and Figueiredo, A. J. (2015). Biological maturation of youth athletes: Assessment and implications. *Br. J. Sports Med.* 49, 852–859. doi: 10.1136/bjsports-2015-094623

Massuca, L., Branco, B., Miarka, B., and Fragoso, I. (2015). Physical fitness attributes of team-handball players are related to playing position and performance level. *Asian J. Sports Med.* 6, 2–6. doi: 10.5812/asjsm.24712

McCarthy, N., and Collins, D. (2014). Initial identification and selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road? *J. Sports Sci.* 32, 1604–1610. doi: 10.1080/02640414.2014.908322

McCarthy, N., Collins, D., and Court, D. (2016). Start hard, finish better: further evidence for the reversal of the RAE advantage. *J. Sports Sci.* 34, 1461–1465. doi: 10.1080/02640414.2015.1119297

Musch, J., and Grondin, S. (2001). Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev. Rev.* 21, 147–167. doi: 10.1006/drev.2000.0516

Nolan, J. E., and Howell, G. (2010). Hockey success and birth date: the relative age effect revisited. *Int. Rev. Sociol. Sport* 45, 507–512. doi: 10.1177/1012690210371560

Pino-Ortega, J., Gómez-Carmona, C. D., Nakamura, F. Y., and Rojas-Valverde, D. (2020). Setting kinematic parameters that explain youth basketball behavior: influence of relative age effect according to playing positions. *J. Strength Cond. Res.* doi: 10.1519/JSC.0000000000003543. [Epub ahead of print].

Pliauga, V., Lukonaitiene, I., Kamandulis, S., Skurvydas, A., Sakalauskas, R., Scanlan, A. T., et al. (2018). The effect of block and traditional periodization training models on jump and sprint performance in collegiate basketball players. *Biol. Sport* 35, 373–382. doi: 10.5114/biolsport.2018.78058

Román Seco, J. D. (2008). Tactical collective of group in attack: the models Spanish handball. *Mag. Sports Sci.* 4, 29–51.

Román Seco, J. D. (2009). La evolución del juego de ataque en balonmano. Revisión histórica: El Siglo XX. *J. Sports Sci.* 3, 47–78.

Rubajczyk, K., Swierzko, K., and Rokita, A. (2017). Doubly disadvantaged? the relative age effect in Poland's basketball players. *J. Sports Sci. Med.* 16, 280–285.

Ruf, L., Chery, C., and Taylor, K. L. (2018). Validity and reliability of the load-velocity relationship to predict the one-repetition maximun in deadlift. *J. Strength Cond. Res.* 32, 681–689. doi: 10.1519/JSC.0000000000002369

Sá, P., Resende, R., Rui Gomes, A., Saavedra, M., and Fernández, J. J. (2020). The relative age in handball players in Portugal. *J. Sports Sci.* 16, 93–102.

Saavedra, Y., and Saavedra, J. M. (2020). The Association between relative age effect, goals scored, shooting effectiveness, and the player's position, and her team's final classification in international level Women's Youth Handball. *Montenegrin J. Sports Sci. Med.* 9, 1–7. doi: 10.26773/mjssm.200303

Schorer, J., Cobley, S., Büsch, D., Bräutigam, H., and Baker, J. (2009). Influences of competition level, gender, player nationality, career stage, and playing position on relative age effects. *Scand. J. Med. Sci. Sports* 19, 720–730. doi: 10.1111/j.1600-0838.2008.00838.x

Schorer, J., Wattie, N., and Baker, J. (2013). A new dimension to relative age effects: constant year effects in German youth handball. *PLoS ONE* 8:e60336. doi: 10.1371/annotation/346754d7-87e5-4e5f-90c8-86a23632227a

Schwesig, R., Hermassi, S., Fieseler, G., Irlenbusch, L., Noack, F., Delank, K. S., et al. (2017). Anthropometric and physical performance characteristics of professional handball players: influence of playing position. *J. Sports Med. Phys. Fitness* 57, 1471–1478. doi: 10.23736/S0022-4707.16.06413-6

Smith, K. L., Weir, P. L., Till, K., Romann, M., and Cobley, S. P. (2018). Relative age effects across and within female sport contexts: a systematic review and meta-analysis. *Sports Med.* 48, 1451–1478. doi: 10.1007/s40279-018-0890-8

Steingröver, C., Wattie, N., Baker, J., Helsen, W. F., and Schorer, J. (2017). Geographical variations in the interaction of relative age effects in youth and adult elite soccer. *Front. Psychol.* 8:278. doi: 10.3389/fpsyg.2017.00278

Vaeyens, R., Philippaerts, R. M., and Malina, R. M. (2005). The relative age effect in soccer: a match-related perspective. *J. Sports Sci.* 23, 747–756. doi: 10.1080/02640410400022052

Ward, P., Coutts, A. J., Pruna, R., and McCall, A. (2018). Putting the "I" back in team. *Int. J. Sports Physiol. Perform.* 13, 1107–1111. doi: 10.1123/ijspp.2018-0154

Wattie, N., Cobley, S., and Baker, J. (2008). Towards a unified understanding of relative age effects. *J. Sports Sci.* 26, 1403–1409. doi: 10.1080/02640410802233034

Wrang, C. M., Rossing, N. N., Diernæs, R. M., Hansen, C. G., Dalgaard-Hansen, C., and Karbing, D. S. (2018). Relative age effect and the re-selection of Danish male handball players for national teams. *J. Hum. Kinet.* 63, 33–41. doi: 10.2478/hukin-2018-0004

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