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# The youth elite football players

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# The youth elite football players

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# Editorial: The youth elite football players

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injury risk, mental health, match performance, recovery, player development, psychological and social factors

Editorial on the Research Topic
The youth elite football players

Youth football player development involves a delicate interaction between football-specific technical, tactical, physical, and mental aspects, as well as various biological, sociological, and cultural conditions. In recent years, this has attracted intensified academic interest. This research topic dedicated to female and male elite youth football players, presents 10 original research papers related to injury risk and mental health, match performance and recovery, player development and talent identification as well as, psychological and social factors.

Improving player well-being and mitigating injury risks in youth football is paramount in preserving long-term development. Two studies by Andersen and colleagues provide insights into these areas, shedding light on the challenges faced by players and the strategies needed to address these effectively.

The first study reveals the load distribution and injury burden in male youth elite players over a full competitive season. Hip/groin injuries emerge as a prominent concern, while knee injuries impose the greatest burden and the most playing time lost. These findings underscore the urgent need for targeted injury prevention measures and comprehensive player management strategies.

The second study addresses the relationship between load exposure, wellness, and psychological variables among male and female youth national team players. It highlights the impact of international competitions on players' physical and mental well-being, with increased stress levels observed during periods of international competitions. Importantly, the study identifies key correlations between stress, load, and well-being, emphasizing the interconnected nature of these factors.

Together, these studies underscore the multifaceted nature of player health and performance in youth football. By leveraging data-driven approaches and implementing evidence-based interventions, stakeholders may effectively safeguard the well-being of young athletes and nurture their potential on and off the field.

Expanding on player performance and recovery, understanding the impact of match demands and recovery intervals is pivotal for optimizing performance. The study by Franceschi et al. examines the reliability and sensitivity to change post-match physical performance measures in elite youth football players. Notably, isometric posterior chain peak force and torque, along with various CMJ parameters, emerged as robust

indicators for monitoring neuromuscular performance. These findings underscore the importance of employing precise assessment protocols to track performance variations and inform targeted recovery interventions. Furthermore, the study by Wilke et al. addresses differences between 48-h and 72-h rest intervals following international tournament matches. While no significant differences were observed in performance or perceptual parameters between the two rest intervals, biochemical markers of inflammation and muscle damage were markedly elevated after matches with shorter rest periods. This highlights the physiological strain associated with compressed recovery timelines and underscores the necessity of adequate rest for player recuperation and injury prevention. Collectively, these studies offer valuable insights into the interplay between match demands, recovery dynamics, and player performance in youth elite football.

Player development and talent identification, requires a nuanced understanding of the factors shaping player fitness, organizational structures, and stakeholder coherence. Three studies shed light on critical aspects of youth elite football development, offering valuable insights for coaches, administrators, and policymakers.

The first study (Gonaus et al.) investigates the decade-long trends in the fitness of elite Austrian youth football players, employing propensity score matching to control for confounding variables. Results indicate notable improvements in speed-related attributes among recent players, highlighting the evolving demands of modern football. However, declines in flexibility and upper-limb power underscore the need for comprehensive training programs that address diverse physical attributes.

A comprehensive survey of operational practices in youth elite football academies and national federations worldwide is presented in the study by Gregson et al. Findings reveal strategic alignment and shared decision-making within medical and performance units, alongside widespread research, and development activities. These insights offer valuable implications for optimizing player development programs and enhancing collaboration across organizational units. Sweeney et al. examines stakeholder coherence throughout the Irish football player pathway, revealing significant gaps in understanding and implementation of developmental principles. While stakeholders demonstrate alignment with talent development principles, inconsistencies in strategic aims and relationships underscore the need for organizational intervention and structural change. Recommendations are provided for fostering stakeholder coherence and aligning policies with long-term player development goals. Together, these studies provide a comprehensive overview of elite youth football development, emphasizing the importance of continuous monitoring, collaboration, and adaptation to meet the evolving demands of modern football. By integrating these insights into practice, stakeholders can enhance player development pathways and nurture the next generation of football talent effectively.

Finally, three studies address achievement, psychological, and social factors in football. For elite male players, release from professional academies may result in psychological distress, with an urgent need for robust support structures to aid players through this transition (McGlinchey et al.). In elite women's football, the decision to persevere or depart is influenced by a myriad of factors, from financial constraints to divergent motivations. While steps have been taken to improve conditions, tailored interventions are necessary to sustain and empower female athletes in their professional pursuits (Bjerksæter & Lagestad). Finally, the interplay between relative age effect and personality constructs underscores the importance of holistic development in youth football. Younger players display higher self-confidence, while older counterparts exhibit greater team orientation. This highlights the need to cultivate well-rounded individuals who can overcome physical disparities through psychological resilience (Bolckmans et al.).

Altogether, the research topic articles underscore the multifaceted nature of youth football player development, addressing critical aspects such as injury prevention, match performance, talent identification, and psychological well-being. Moreover, the studies emphasize the importance of continuous monitoring, evidence-based interventions, and tailored support structures to nurture the next generation of football talent effectively. By integrating these insights into practice, stakeholders may navigate effectively fostering holistic growth, resilience an improved performances among female and male youth elite football players.

## Author contributions

TA: Conceptualization, Writing – original draft, Writing – review & editing. JM: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. MR: Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# The Irish Football Player Pathway: Examining Stakeholder Coherence Throughout and Across the Player Development System

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Maximizing the efficiency of the player development system is a strategic priority for any professional football club or association. However, the successful development of a young footballer is largely dependent upon the roles and relationships of the different stakeholders invested in the developmental process. This study examined the level of horizontal (i.e., extent to which stakeholders across a pathway stage work with players in an agreed fashion to optimize their experience) and vertical (i.e., extent to which multiple stages of the pathway are coordinated and build chronologically from previous involvement toward long-term needs) stakeholder coherence throughout the Irish football player pathway following a restructuring of development policies and the implementation of a nationwide academy system between 2016 and 2020 under the Football Association of Ireland's (FAI) Player Development Plan. As a second aim, we explored each of the key stakeholders' alignment to academic talent development principles in order to provide practical recommendations for future player and coach development policies. Accordingly, a series of interviews were conducted with 31 key stakeholders currently engaged in the player pathway. These key stakeholders consisted of parents, coaches and members of the FAI as the National Governing Body for football in Ireland. Data were analyzed using Reflexive Thematic Analysis, with findings highlighting a lack of stakeholder coherence across the pathway, both vertically and horizontally. Stakeholders displayed inconsistency in their understanding of the purpose of the player pathway and its long-term strategic aims, as well as demonstrating poor and incohesive relationships with each of the different stakeholders. Moreover, talent development principles between the different stakeholders appeared well-understood overall, although the practical implementation of several of these principles in applied practice did not appear to exist. Results highlight the need for organizational intervention and structural change across the Irish player pathway to maximize long-term player development in the future. Practical implications for the FAI are discussed and recommendations are made to support optimal player development policies moving forward.

**Keywords: academy football, talent development, talent pathway, stakeholder coherence, talent development principles, Irish football player pathway**

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## INTRODUCTION

Every year, professional football clubs enroll thousands of youth players into their respective talent development systems, otherwise known as academies (Ford et al., 2020; Williams et al., 2020). Within the academy system, well-funded coaches, scouts, sports scientists, and administrators are employed to engage in the process of developing these high potential youth players (Ford et al., 2020). However, the process of talent development is complex. Indeed, while the development and subsequent success of a talented young player is influenced by a variety of innate, psychological and behavioral factors, the successful progression of a young player is also largely dependent upon their specific talent development environment (Mills et al., 2014a,b). Young players will simultaneously engage with various sporting environments (i.e., grassroots clubs, academies, national representative squads) and stakeholders (i.e., parents, coaches, peers) throughout their time in the talent pathway. Given both the complexity and variation in the environments that young athletes inhabit, Henriksen et al. (2010a,b) emphasize the importance of a holistic ecological approach to development, noting that effective talent development environments are characterized by a high degree of cohesion and cooperation with a considerable focus on organizational structure and culture. Martindale et al. (2007) characterized the key principles encompassing effective development environments for young athletes and identified that (1) developing long-term aims and methods, (2) providing wide-ranging coherent messages and support, (3) emphasizing appropriate development, not early success, (4) providing individualized and ongoing development, and (5) providing integrated, holistic and systematic development as characteristics of effective talent development environments. A shared and coherent understanding of these principles between the stakeholders involved in developing young athletes is vital in maximizing athlete progression to elite senior levels (Curran et al., 2021).

In football, talent identification is primarily concerned with selecting pre-pubertal athletes and talent development focuses on their development as they progress throughout puberty into adulthood (Pankhurst and Collins, 2013). Multiple stakeholders play a role in the talent development process, namely the National Governing Body [NGB] (or academy), the club, coaches, and the athlete's parents (Pankhurst and Collins, 2013). Parents' role in the talent development process has been highlighted regularly within research (e.g., Côté, 1999; Gould et al., 2002, 2006; Wolfenden and Holt, 2005). Parents adopt a leadership role during their child's sampling years of development, shifting to a follower/supporter role during the specializing and investment years of development (Côté, 1999). Parents also provide emotional support as their child experiences the psychological stress and challenges of high-level competition (Côté, 1999), which is vital given the non-linear and challenging nature of the "rocky road" to the top (Collins and MacNamara, 2012). Alongside parents, there is a plethora of research attesting to the central role of coaches in supporting talent development in youth sport (i.e., Wolfenden and Holt, 2005; Henriksen et al., 2010b; Abraham and Collins, 2011) and within youth football specifically (i.e., Smith and Cushion, 2006; Cushion et al., 2012; Larsen et al., 2013; O'Connor et al., 2018). Within football, coaches have significant influence and control over player development and the sociocultural dynamics of the learning environment (Cushion et al., 2012). The actions of the coaches impact the behavior, cognition, and affective responses of players, and have a marked influence on young players' overall development (Cushion et al., 2012). Crucially, coaches are often the individuals responsible for identifying talent, although their role in this talent identification process is influenced by their experiences in a specific coaching culture (Lund and Söderström, 2017). The NGB, as the third stakeholder and "system controller," has responsibility for the policies and systems in the sport, including the coach education system (Pankhurst and Collins, 2013). However, in comparison to the other two stakeholders, the role of the NGB in talent identification and development has attracted relatively less research attention.

The extent to which there is alignment in perceptions across each stakeholder is another crucial element in player development. As Pankhurst and Collins (2013) highlight, the success of a young athlete depends upon each key stakeholder deploying their specific skills, having commonality in their knowledge of athletic development, and an understanding of the talent identification and development process itself, in addition to the existence of quality relationships between each of these key stakeholders. A lack of coherence between stakeholders can impact a young player's success as a result of mixed messages, confused agendas and a lack of clear direction and directives (Pankhurst and Collins, 2013). Indeed, coherence is a characteristic of effective talent development environments (Martindale et al., 2007), represented by inputs that are structured, complementary and framed against long-term agendas (Webb et al., 2016). In essence, a coherent operating system is the strategic center of an efficient development environment, and a cohesive philosophy between stakeholders, characterized by clearly defined core values, expectations, and behavioral standards, represents optimal developmental conditions for young football players (Mills et al., 2014a). Stakeholder coherence can be seen horizontally where athletes experience complimentary coaching and adaptive support based upon changing demands, and coherence can also be seen vertically, where multiple stages of the pathway build chronologically from previous involvement toward long-term aims (Taylor and Collins, 2021).

In an investigation into the talent development environments of elite football academies in Sweden, high-quality environments were characterized by well-established relationships between key stakeholders, whereas in low-quality environments, academy players experienced deficiencies in their support network with a lack of established relationships between stakeholders, particularly between coaches and parents (Ivarsson et al., 2015). In a similar investigation framed within a UK context, Mills et al. (2014a) qualitatively examined the factors perceived by ten expert coaches from ten professional football academies to underpin optimal talent development environments specific to football. The findings highlighted the need for an integrated

approach to talent development that establishes a strong link between players, parents and club staff. In essence, optimal player development environments appear to be, at least in part, driven by the existence of coherent stakeholder relationships. In this regard, Pankhurst et al. (2013) note that a lack of stakeholder coherence is a barrier to long-term athlete development, and the chances of success for a young athlete appear to be enhanced if all the stakeholders in the development pathway have similar perceptions of the key elements of talent identification and development, and therefore, have similar behaviors and support systems. Unfortunately, a lack of organizational proximity and communication between youth and professional environments has been observed in many elite football clubs across Europe, hindering youth players' progression into professional football (Relvas et al., 2010). Likewise, several recent investigations into the talent pathways of football academies in the UK have identified a lack of horizontal coherence across the pathway, characterized by low levels of communication between coaches and parents (Harwood et al., 2010; Clarke and Harwood, 2014; Mills et al., 2014b).

Whilst the knowledge, skills, and abilities of each stakeholder are unique and specific to the athlete, there is a need for consistency and clarity in messages and support between the stakeholders if the potential of a player is to be realized (Martindale et al., 2005; Pankhurst et al., 2013). In most talent identification and development systems, stakeholder understanding of the fundamentals of the key constructs of any process is presumed to exist, although research thus far does not appear to support this presumption (Pankhurst et al., 2013). However, there is a lack of empirical evidence about how coherence can be realized in regard to the methods, structures, and opportunities that young athletes are afforded as they progress within a complex talent pathway. As a result, there have been calls for further research to provide clarity in this area (cf. Pankhurst and Collins, 2013; Pankhurst et al., 2013; Webb et al., 2016). Indeed, there is a growing research base that has sought to examine talent development environments in a youth football context (i.e., Larsen et al., 2013; Aalberg and Sæther, 2016; Flatgård et al., 2020; Larsen et al., 2020). However, despite providing valuable additions to the talent development literature, these investigations have predominantly focused on a single football club or age group in a non-Irish cultural context. Whilst similarities in talent development environments can exist at their core, development environments are highly individualized and culturally specific (Henriksen et al., 2010a; Mills et al., 2014b). Examining the cultural context of talent pathways is especially important given the over-arching and systematic influence culture has on the development of talent (Martindale et al., 2007).

The Football Association of Ireland (FAI) is the NGB for football in Ireland. Between 2014 and 2019, the FAI introduced the under 17, 15, and 13 (changed to under 14 in 2020) underage National Leagues (NL), respectively, to enhance the development of players in Ireland. The introduction of the underage NL required senior NL clubs (also referred to as League of Ireland clubs) to create affiliated academy squads from the under 13 to under 19 age cohorts, similar to the academy system seen in professional clubs elsewhere throughout Europe. Before the introduction of the underage NL, no academy system in Ireland existed and schoolboy football clubs (also referred to as grassroots football clubs) were responsible for the development and transfer of players to professional clubs abroad, particularly to clubs in the UK. Schoolboy football clubs are governed by the Schoolboy Football Association of Ireland (SFAI), which is an affiliate of the FAI. The SFAI has 30 separate football leagues throughout Ireland, with each schoolboy football league also governed independently by their individual league council. This makes the dynamic of the Irish football landscape particularly complex and cumbersome, with each schoolboy football league operating independently from one another under the jurisdiction of the SFAI, and the SFAI operating independently from the FAI. Prior to the introduction of the NL, large schoolboy clubs in the Dublin District Schoolboy League (DDSL[1]) dominated schoolboy competitions and, due to the number of players from this select number of grassroots clubs signing for professional clubs in the UK, were considered by many to be best clubs for high potential players from around Ireland to play for. This led to players from different parts of Ireland traveling large distances to play in the DDSL. The NL were introduced by the FAI to provide a consistently higher quality of youth coaching and competition nationwide so that players in every county had the opportunity to avail of coaching and playing environments that are better suited to their needs. This decision was a radical intervention in player development in Ireland and caused significant unrest among the SFAI and many of its member clubs.

This study aimed to explore the extent of horizontal and vertical coherence across the Irish football academy pathway and to explore the key stakeholder perceptions of, and alignment to, talent development principles. Given the lack of previous research investigating how the introduction of the new Irish football academy pathway impacts each stakeholder, the nature of this research was considered timely. As Mills et al. (2014a) note, "[our] knowledge of athletic development environments is far from complete, particularly where elite youth soccer is concerned" (p. 138). To bridge this gap, qualitative interviews were conducted with the key stakeholders across the Irish football pathway: parents, coaches (from both schoolboy clubs and NL clubs), and the FAI as the NGB. This was the first research of its kind to critically and comprehensively analyse the extent of stakeholder coherence across the Irish football academy pathway, and consequently, this research was considered necessary to optimize future player development and coach development policies within the FAI.

# METHODOLOGY

## Research Philosophy

Given the purpose of this study and our aim to generate practically meaningful knowledge, this study was grounded by a pragmatic research philosophy. A pragmatic research philosophy is one that employs methods with the aim of answering questions

[1]DDSL: The Dublin District Schoolboy League is the largest of the thirty schoolboy football leagues in Ireland.

and providing practical solutions, rather than being driven by a distinct epistemological approach (Giacobbi et al., 2005). Pragmatic approaches also suggest the prioritization of questions and methods that are practically meaningful rather than seeking generalisable truths or subjective constructions (Taylor and Collins, 2021). Pragmatism maintains that researchers are not passive observers, and as such, it was important to note that all authors have experience working with talent pathways and in the context under investigation in particular. Our positioning as practitioners familiar with the context facilitated novel and innovative insights (Bryant, 2009) and formed the platform for a detailed enquiry, allowing us to combine our applied experience with relevant literature, considering ourselves as co-constructors of knowledge, attempting to generate meaningful information. Reflecting our pragmatic approach and the aim of this research, a qualitative methodological approach in the form of one-to-one interviews was adopted to allow for an in-depth investigation of the perceptions and experiences of the pathway from the perspectives of each individual stakeholder. Underpinned by this approach, we embraced the experiences, realities, and reflections of each stakeholder engaged in the Irish football player pathway.

## Participants

Thirty-one participants were purposefully recruited based on their current involvement in the Irish football pathway. Participants were subdivided into separate samples of parents [P] ($n = 9$) aged between 44 and 53 years (M = 49.4 years; SD = 3.0 years), Schoolboy football club coaches [SC] ($n = 8$) aged between 33 and 58 years (M = 43.4 years; SD = 7.3 years), NL academy coaches [NLC] ($n = 10$) aged between 23 and 53 years (M = 35.8 years, SD = 9.3 years), and coaching/coordinating personnel from the FAI underage national coaching system [FAIC] ($n = 4$) aged between 30 and 65 years (M = 42.3 years; SD = 16.5). All participants were recruited from an evenly distributed geographical sample to provide a nationally representative spread of participants across the country. Moreover, such a spread of coaches was selected to provide a representation of all levels of Irish underage football, from schoolboy level through to the national level, with each coach deriving from a different club. All coaches were coaching at the under 14 to under 17 age groups at the time of data collection, and all parents had a child currently signed to a NL academy in the pathway at the under 14 to under 17 age groups. Given the introduction of the new underage NL and academy infrastructure in Irish football under the (Football Association of Ireland Player Development Plan, 2015), each participant's engagement in the pathway under the current system ranged from 1 to 5 years at the time of data collection.

Our research focussed on the player development pathway for male players only, as at the time of data collection, the under 14 and 15 NL existed for male populations only. Following ethical approval by the first author's institutional Research Ethics Committee, all participants were invited to participate through personal contact *via* gatekeepers within the League of Ireland and at the FAI. After agreeing to participate in the study, all participants were contacted by email and, where necessary, by telephone by the first author, informed of the purpose of the investigation and assured of confidentiality. All participants were provided with a participant information document before providing informed consent.

## Data Collection

To maintain relevance to the research questions, a semi-structured interview guide with open-ended questions and relevant follow-up prompts was reflexively adhered to. The interview guide was underpinned by relevant literature and the authors' knowledge and experiences of Irish football and talent development environments. Questions revolved around various experiences and perceptions of the Irish football pathway (i.e., What is your understanding of the FAI player pathway? What are the objectives of the underage National Leagues? What are the coaches from the National League clubs looking for in players during talent identification?), with probes and prompts used to clarify and expand on specific points (i.e., Are these the right things in your opinion? How does that influence what you do in your role?). The interview guide was tested and refined through pilot work with three Irish football coaches aged between 38 and 55 years (M = 44.3 years; SD = 9.3), all of which were qualified at a minimum of the UEFA A coaching License, with between 4 and 25 years of coaching experience (M = 9.3 years; SD = 10.5 years). The interview guide is available on request from the first author.

Interviews were conducted between each participant by the first author. Interviews were conducted electronically *via* video interviews using the Zoom video software (Zoom Video Communications, San Jose, California, USA) to ensure adherence to the national government's COVID-19 pandemic safety regulations at the time of data collection. In instances where face-to-face interviews are unfeasible, Zoom electronic video interviews are recommended as an alternative method to gather rich data, whilst facilitating a positive participant experience (Gray et al., 2020). Interviews were conducted with the first author and each participant in a quiet location, and a pre-briefing allowed participants to reflect upon the themes to be discussed and provided an opportunity for further questions. Excluding an initial briefing and warm-up questions, interviews lasted between 43 and 81 min (M = 60 min; SD = 10 min) and were video and audio recorded for subsequent transcription and analysis. Manual transcription was conducted by the first author, with transcription documents then re-checked against audio recordings to confirm transcription accuracy.

## Data Analysis

Reflexive thematic analysis (RTA) (Braun and Clarke, 2019, 2021) was conducted to analyse the content of the interviews. RTA "is about the researchers reflective and thoughtful engagement with their data and their reflective and thoughtful engagement with the analytic process" (Braun and Clarke, 2019, p. 594). Cohering to the interpretive style of RTA, analysis was predominantly conducted by the first author, and consequently, the results of the analysis reflect the first author's interpretation of data. Given the nature of RTA (cf. Braun and Clarke, 2019, 2021), interviews were conducted with flexibility and fluidity to resemble the flow of a real-world conversation, with considerable scope for the researcher to be spontaneously responsive to the participants'

unfolding accounts. Such an approach allowed the author to gain an in-depth exploration of each participant's story, rather than a uniformly structured account. This flexible and fluid approach to interviewing was considered appropriate for extracting each participant's perceptions, beliefs and experiences of the Irish football player pathway. Using an inductive "bottom-up" approach, data was open-coded with a focus on deriving semantic and latent codes and themes strongly linked to the data itself. However, deductive analysis was also employed to ensure that open coding produced themes relevant to the research question. An experiential orientation to data interpretation was adopted to emphasize meaning and experience expressed by participants, and epistemological theoretical considerations for analysis were essentialist, meaning language was interpreted as a reflection of participant meaning and experience.

Data was analyzed using Braun and Clarke's (2019, 2021) six-phased approach to RTA. Data was manually and orthographically transcribed to Microsoft Word (Windows Microsoft, Washington, USA) to facilitate deep immersion in the data, each transcript was then re-read several times, and familiarization notes were taken to ensure familiarity and understanding of the data before systematic data coding began. Once data was coded, initial themes were generated from the codes. Potential themes were then developed and reviewed and structured into a framework of higher-order themes, followed by the refining, defining and naming of themes based upon the content of the codes within each theme. The sixth and final phase consisted of writing the report, although given the reflexive nature of RTA (Braun and Clarke, 2019, 2021), report writing was recursive and woven into the entire process of the analysis. The qualitative analysis software (QSR NVIVO-12) was used to assist in the structuring, organizing and analysis of raw data into their thematic hierarchies.

## Trustworthiness

The first author was experienced in the Irish football environment at NL level which brought familiarity and awareness with participants on the topics being discussed throughout each interview. These factors helped build trust and rapport with participants which supported the breadth and depth of information provided. Throughout data analysis, the first author kept a reflexive journal to record their reflections and insights throughout data collection, and also to use the practice of writing as a tool for deepening reflexivity (Braun and Clarke, 2021). Given the interpretive and reflexive nature of RTA, analysis was predominantly conducted by the first author, with the second author auditing the reflexive analytical process by sense-checking analysis and exploring other alternative interpretations of data. This process encouraged reflexivity by challenging the first author's construction of knowledge in a way that was collaborative and reflexive, aiming to achieve richer interpretations of meaning, rather than to achieve consensus of meaning (Braun and Clarke, 2019; Byrne, 2021).

# RESULTS AND DISCUSSION

This study aimed to examine the extent of horizontal and vertical stakeholder coherence across the Irish football academy pathway and to explore the key stakeholder perceptions of, and alignment to, talent development principles. The RTA produced two themes (stakeholder coherence and alignment to talent development principles), seven higher-order themes, and 15 lower-order themes which are displayed in **Table 1**. These higher-order themes and lower-order themes are subsequently presented in detail with exemplar quotations below to illustrate the analysis.

## Stakeholder Coherence

### Horizontal Coherence

A lack of horizontal coherence was apparent at the NL level, as evidenced in the relationships between coaches and parents. Eight NL coaches cited experiences of interference from parents, specifically parents applying excessive amounts of pressure on their children and parents providing contradictory and inappropriate coaching advice. The majority of coaches cited overbearing parents as one of the biggest barriers faced at the internal club level, and explained how these parents hinder their ability to perform their role as coaches effectively:

> *"The first year was tough. I had parents who were quite opinionated, who were vocal on the side-line, who would completely contradict the information that the players were getting from us in their eight hours in training. We spend eight hours a week or five hours with the kids and we would be telling them this and then the parents would completely change that and then the player becomes quite conflicted in what to do"* [NLC6].
>
> *"I've seen it with young lads, and nobody is perfect, and we all have bad days and sessions and things like that, but to see a kid get into a car with a parent and the parent tears strips off of the child because they missed a pass or missed a goal or something like that, that's where you as a coach have to be going to the parent and saying 'that's not your job, its mine. I'll talk to him' (…) some kids are afraid for their life!"* [NLC3].

Côté (1999) highlighted the important role of parents during athlete development through the provision of emotional support as their child experiences the psychological stress and challenges of high-level competition. The results here indicate that a proportion of parents are behaving in ways that can negatively influence long-term athletic development (i.e., providing inappropriate coaching advice, putting pressure on their child). Similar behaviors have also been observed in the parents of English academy players by Mills et al. (2012) and highlight the need for further and more comprehensive parental education; another theme that emerged from this research. Six participants commented on the need for more parental education to help parents understand their role as "football parents," but also to help parents understand the roles of the coaches and other key stakeholders. For instance, as the child enters the academy at the specialization stage of development, the responsibility for the child's sporting development transfers from the parent to the coach, and parents must accept this transference of responsibility and adopt a role of support for their child (Côté, 1999; Clarke and Harwood, 2014). This need for parental education was exemplified by the reflections of P1:

> *"I also think parent education [is needed], because people think that shouting on the side-lines at their son or at the referee… let me tell*

**TABLE 1 |** The themes, higher order themes, and lower order themes produced from the reflexive thematic analysis.

| Theme | Higher order themes | Lower order theme | Raw data theme | Mentioned by participants (%) | | | |
|---|---|---|---|---|---|---|---|
| Stakeholder coherence | Vertical coherence | Lack of shared understanding regarding the purpose of the player pathway | Generate finances from selling players to clubs abroad | 40% NLC | 75% SC | 56% PAR | 25% FAIC |
| | | | Provide a pathway to first team football | 80% NLC | 25% SC | 33% PAR | 25% FAIC |
| | | | Produce players for Irish international teams | 60% NLC | 20% SC | 33% PAR | 75% FAIC |
| | | | Provide an environment for the best players to play with and against the best players | 50% NLC | 38% SC | 44% PAR | 25% FAIC |
| | | | Increase the standard of domestic football | 50% NLC | 13% SC | 11% PAR | 25% FAIC |
| | | Disjointed relationships between National League and schoolboy clubs | The poor relationship between National League clubs and schoolboy clubs is hindering player development | 100% NLC | 100% SC | 89% PAR | 75% FAIC |
| | | | Schoolboy clubs are reluctant and uncooperative in transferring players to the National League clubs | 90% NLC | 50% SC | 78% PAR | 75% FAIC |
| | | | Schoolboy clubs dislike the loss of power caused by the introduction of the National Leagues | 70% NLC | 33% SC | 56% PAR | 75% FAIC |
| | | | National League clubs inappropriately approach players without cooperating with schoolboy clubs | 20% NLC | 25% SC | 33% PAR | 25% FAIC |
| | | | The misalignment in youth football seasons is hindering player development | 0% NLC | 25% SC | 22% PAR | 50% FAIC |
| | | Poor relationship between the FAI and the SFAI | The FAI and SFAI do not cooperate or communicate | 30% NLC | 38% SC | 44% PAR | 50% FAIC |
| | | Conflicting opinions regarding the quality of coaching throughout the pathway | The standard of coaching in the National Leagues is optimal for player development | 100% NLC | 25% SC | 100% PAR | 0% FAIC |
| | | | The style of play being coached in the National Leagues is poor | 10% NLC | 63% SC | 0% PAR | 25% FAIC |
| | | | Higher quality coaching needs to begin at earlier ages | 60% NLC | 13% SC | 22% PAR | 50% FAIC |
| | | | The quality of coaching at the schoolboy level is generally poor | 90% NLC | 63% SC | 56% PAR | 25% FAIC |
| | | | The quality of coaching at the schoolboy level and in the National Leagues is the same | 0% NLC | 38% SC | 0% PAR | 0% FAIC |
| | Horizontal coherence | Poor relationships between coaches and parents within National League academies | Parents of academy players can be overbearing | 80% NLC | 0% SC | 33% PAR | 50% FAIC |
| | | | Lack of communication from coaches to parents | 0% NLC | 0% SC | 56% PAR | 0% FAIC |
| | | | Lack of parental education | 10% NLC | 25% SC | 22% PAR | 25% FAIC |
| | | | Open and regular lines of communication exist between National League coaches and parents | 50% NLC | 0% SC | 11% PAR | 0% FAIC |
| | | Concerns over the youth to senior transition | There is a divide between academy teams and the senior departments at National League clubs | 50% NLC | 13% SC | 22% PAR | 50% FAIC |
| Alignment to talent development principles | Early engagement | Football player engagement | Academy players have given up other sports to focus on football | 70% NLC | 0% SC | 56% PAR | 0% FAIC |
| | | | When players enter the academy pathway the majority of their sporting activity should be devoted to football | 60% NLC | 25% SC | 44% PAR | 75% FAIC |
| | | | Football free play is essential for development | 40% NLC | 13% SC | 11% PAR | 0% FAIC |
| | | Opinions about engagement in other sports | There are biopsychosocial benefits of playing other sports | 90% NLC | 63% SC | 89% PAR | 100% FAIC |
| | | | Academy players should be encouraged to recreationally participate in other sports on non-football days | 50% NLC | 0% SC | 33% PAR | 75% FAIC |

*(Continued)*

**TABLE 1** | Continued

| Theme | Higher order themes | Lower order theme | Raw data theme | Mentioned by participants (%) | | | |
|---|---|---|---|---|---|---|---|
| | | | Sampling other sports is important during the childhood years of development | 70% NLC | 75% SC | 89% PAR | 100% FAIC |
| | | Irish culture | The GAA is an important part of Irish culture | 70% NLC | 63% SC | 44% PAR | 25% FAIC |
| | | | Irish culture is multiple sport participation | 50% NLC | 38% SC | 11% PAR | 0% FAIC |
| | Systematic barriers to | Lack of appropriate resources in the National Leagues | Lack of facilities | 70% NLC | 75% SC | 22% PAR | 100% FAIC |
| | player | | Lack of financial investment in Irish football | 40% NLC | 38% SC | 22% PAR | 25% FAIC |
| | development | | Lack of a full-time football industry | 90% NLC | 13% SC | 0% PAR | 25% FAIC |
| | Biological maturation | Early maturation selection biases | Player selection is based upon physical attributes | 30% NLC | 63% SC | 89% PAR | 0% FAIC |
| | | | Later developing players are overlooked in selection | 20% NLC | 50% SC | 33% PAR | 0% FAIC |
| | | Lack of developmental opportunities for later maturing | National League age gaps hinder later maturing players | 30% NLC | 38% SC | 22% PAR | 50% FAIC |
| | | players | Players should be matched by physical size rather than age | 20% NLC | 13% SC | 11% PAR | 0% FAIC |
| | Lack of | Uncompetitive matches | Large score-lines and uncompetitive matches | 50% NLC | 50% SC | 56% PAR | 25% FAIC |
| | appropriate | Lack of contact hours | Lack of training hours | 70% NLC | 13% SC | 33% PAR | 50% FAIC |
| | challenge | | Lack of matches | 20% NLC | 25% SC | 0% PAR | 0% FAIC |
| | An emphasis on short-term success | A focus on short term results | A focus on winning matches | 70% NLC | 38% SC | 56% PAR | 50% FAIC |

*FAIC, Football association of Ireland coaches; NLC, National League academy coaches; PAR, Parents; SC, Schoolboy football club coaches.*

*you, I was guilty of it and I am horrified by it, the kids feed off of that. If you're going to bring kids through football and it's about the journey, parents are inextricably linked to the child. The kid gets brought every day, and the chances are that it's the father in my experience, but the fathers are the worst, they are the absolute pits of it, and there has to be an educational piece for them to understand because they're the ones on the side-lines dictating."*

The need for parental education was reciprocated among NL coaches:

*"I think more can be done with parents to help them understand it. I find that there is a lot of, well maybe not a lot, but there are parents that want the success now. If their children aren't being looked at for Irish assessments, or if their children aren't starting every game, or if the child is coming off after 30 minutes in every game, the parents seem to want answers"* [NLC4].

Indeed, the need for parental education and regular coach-parent communication within football academies has been highlighted elsewhere (Harwood et al., 2010; Clarke and Harwood, 2014; Newport et al., 2020). Although NL coaches in this study claimed that they do have open and regular lines of communication with parents, the majority of parents were critical of coach communication and believed the level of communication from coaches to be insufficient. This has also been observed in the parents of academy players in the UK, where parents felt that they received inadequate communication and were underappreciated in their role as parents by coaches (Harwood et al., 2010; Clarke and Harwood, 2014). Mirroring these findings, parents in this study expressed a desire for more regular and comprehensive communication from coaches, as P8 explained:

*"There is a certain vacuum around communication with the club…they're not great, their engagement isn't great with the parents if I'm being honest. They give you the bare minimum and they expect a lot with the kids to be there three days a week for two hours and they work them really hard. You're travelling every weekend. They could manage the parent piece better."*

Ten participants also raised concerns over the youth to senior transition in the NL. Specifically, participants expressed how they believed there to be a divide between the senior hierarchy and underage teams within NL clubs, with clubs viewing their underage teams as an inconvenience rather than in a positive developmental light, as NLC1 explained:

*"What I would say is that certain [National League] clubs do not take it serious and probably only have underage teams to make sure they get their licence, and that would be a massive criticism of some clubs; that you know when you're going to play them that they're not really bothered about how their under 14s or 15s get on, it's just something they have to do to tick a box to make sure they get a licence. And there would definitely be some clubs that if you offered them or said to them 'you don't need a 14s, 15s, or 17s and you'll still get your license', I'd say they'd get rid of them in a heartbeat."*

A lack of coherence between youth academies and senior departments within professional football clubs is not uncommon and is purported to hinder players' youth to senior transition (Relvas et al., 2010). Participants also raised concerns over how

the current alignment of age structures within the NL prevented an appropriately staged increase in challenge for young players and was too big of a jump for many players. In response, participants expressed the need for an intervention to bridge the gap between youth and senior football at the exit phase of the pathway:

> *"The only other issue I would have is at the top end of the pathway at the under 19s with keeping the players a wee bit longer. Most clubs do not have a reserve team or a league they can put them into so there is no point in us having everything brilliant at the bottom of the pathway if it gets to the end and it's bottlenecked" [NLC10].*
> *"For me, rather than letting players go at 19 years of age and bringing them back and signing them at 21, 22, 23 years of age, why can't we have that under 21s and… should we be bridging that gap there? That's my own thoughts on it"* [NLC8].

### Vertical Coherence

All participants reported how a disjointed and fractious relationship existed between NL clubs and schoolboy football clubs. Specifically, twenty-nine participants explained how this fractious relationship was the most fragmented element of the player pathway and was subsequently hindering long-term player development. Typifying this, NLC10 commented:

> *"There is no relationship between the schoolboy's football and the league of Ireland clubs up here, it's non-existent. It makes our job more complicated every year. It's more work for me and my coaches, and more work for the schoolboys as well, but who loses out? It's the players."*

The disjointed and incoherent relationship between schoolboy clubs and NL clubs was considered to be hindering player development by all schoolboy coaches, as exemplified by SC8, who expressed the need for urgent intervention:

> *"I could go on and on about it, but it needs someone to go in and grab it by the scruff of the neck, and it would need to be a high profiled guy that has a bit of common sense and has a love of the grassroots and has an interest in the league of Ireland and has an interest in seeing the elite players progress and to have a proper pathway. At the moment, it is a bit disjointed."*

The majority of parents and FAI coaches reiterated that this divide in the pathway was negatively impacting long-term player development. Mills et al. (2014a) described a coherent operating system as the center of an optimal football player development environment, emphasizing the need to develop positive working relationships with both internal *and* external stakeholders. Our findings indicate that NL academies have not established strong cohesive relationships with the schoolboy clubs.

This disjointed pathway was epitomized by the reluctance of schoolboy clubs to allow their players to transfer to NL academies, despite this being the natural vertical progression. Nine NL coaches expressed frustrations over how schoolboy clubs were being intentionally uncooperative in the transfer of players and were actively discouraging players from joining NL academies. Typifying this, NLC3 explained:

> *"I won't mention the clubs, but even we have a lot of trouble with a certain club in [Names Location]. They discourage their players from going and playing National League! Because all they want to do is win a youth cup or a national cup and they want to have it on their role of honour that they won that. But in my mind, they're holding back young lads! (…) I just think some clubs, the way they go on and discourage it [the National League], it's not good for young lads, it's not good for the kids."*

The reluctance of schoolboy football clubs to allow players to progress into NL academies was also cited as an issue for parents:

> *"I think what everybody knows, and from my perspective as a parent, my experience of moving from the schoolboys to the league of Ireland was not nice. There was an absolute clash between the junior [schoolboy] club and the league of Ireland club. They were at loggerheads and couldn't agree"* [P1].
> *"There's resistance, and anecdotally I can tell you that there is this idea that there are people in [schoolboy] clubs who are being very awkward. For example, a certain schoolboy club refused to transfer players by the June 1st deadline just to be awkward. The lads were then effectively on gardening leave and they couldn't play for their league of Ireland club because the schoolboy club didn't sign the forms because they weren't legally obliged to do so. That kind of sh*thousery is kind of rife"* [P9].

Contrastingly, eight participants, including two NL coaches, explained how NL clubs often contact and attempt to sign players from schoolboy clubs without communicating or seeking approval from the schoolboy clubs first. Similar accusations have historically been made between schoolboy clubs before the NL began. However, this approach by NL clubs was perceived to heighten the conflict between the two entities, as illustrated by SC1:

> *"I've had league of Ireland clubs contact parents directly behind my back while the players have been signed to my club. I've had RDO's [Regional Development Officer's] go directly to players (…) I know there have been other trials in other counties where [National League] clubs have not been honest with me, and I still wished those players the best of luck when they left because there's no point in falling out with them because life's too short, but I didn't help that club next time they came asking."*

Under the current pathway, many schoolboy football league seasons, such as the DDSL, run from September to May, whereas the NL seasons run from March to November, with both seasons having conflicting registration periods. Epitomising the lack of vertical coherence, schoolboy and NL seasons were previously aligned (March–November), but in 2019 several schoolboy leagues reverted back to the September to May season. This season misalignment was suggested as a barrier to player development by six participants and meant that schoolboy clubs were subject to losing numerous players once the NL seasons begin, resulting in uncertainty over playing squads and likely heightening the reluctance of schoolboy clubs to let players transfer to NL club's mid-season. Such frustrations can be demonstrated by SC4:

*"One of the big things is that we need to get alignment between schoolboy football and National League football seasons because at the moment it is sort of farcical. I look at my age group at under 14, we will start off the season great, we will have 14 teams in the league, we get to December or January and the likelihood is we will lose several teams and there will be a big gap of players because other league of Ireland clubs will take players from the DDSL."*

The under 14 Kennedy Cup, an interleague competition for the 30 schoolboy leagues in Ireland, has traditionally been seen as a shop window for the best players from the 30 schoolboy leagues in Ireland to attract the interest of professional clubs in the UK. The introduction of the NL at under 13/14 meant that many of the highest potential players in the country at that age were playing for NL clubs and were no longer available to play for their schoolboy leagues in the Kennedy Cup. Participants expressed a belief that this loss of control and the transfer of power to the NL clubs has caused feelings of envy and jealousy amongst many schoolboy clubs who traditionally would have held control over player development in Ireland. This is exemplified by the reflections of NLC6:

*"Historically, the schoolboy clubs in Dublin would have produced the players and they still feel aggrieved that they got it taken off them overnight. They feel that they can produce players and they do have a history of producing players. (…) So, I think that's it, it's a loss of control and a loss of power."*

This divide between schoolboy and academy football was perceived to be caused by the poor historical relationship between the FAI and SFAI. This poor relationship was characterized by a lack of cooperation and communication, with an unwillingness to establish positive working relationships:

*"I think the old sort of analogy of you've got so many kings, and no one wants to lose control of their own palace or their own castle or whatever. I'm assuming, well I'm sure that there's a lot of historical issues there. I think there may potentially be some issues between the SFAI and the FAI which is obviously not allowing them to sit down and come together to create what the best solution is for player development in this country. So, I think you've got a massive issue there"* [FAIC3].

A lack of coherence was also apparent in the disparity of participants' understanding of the purpose of the NL. Parents explained how they felt that NL clubs were focusing on player development, but this focus was based on producing as many players as possible to be sold to foreign clubs to generate finances, rather than for the wider benefit of Irish football, as P3 explained:

*"The progressive Irish clubs will be looking for players with skill, but I fear it might be just to make a killing on the player. I think they're thinking that if a player comes good, they could take in loads of them and even those who aren't good and they can coach them, and then get them flogged off to an English club and make money. I think a lot of it is down to money."*

The majority of schoolboy coaches agreed, expressing a belief that the reason for the implementation of the NL was economically driven, as SC5 explains:

*"My opinion on it [the National Leagues] a couple of years ago hasn't changed from what it is now; I think it was a way for the FAI to get money into the league of Ireland clubs because if you look at the money certain [schoolboy] clubs were getting for getting players over to England, like one of the north side clubs would have been doing very well with that and would have been pocketing a fair few bob. In my opinion, at the beginning, I felt it was about getting money into the league of Ireland clubs without having to do it themselves, and I still would be of the same opinion."*

With young players transferring from schoolboy clubs to NL clubs at earlier ages, this reduces the proportion of the transfer fee schoolboy clubs receive if a player transfers to a professional club abroad. This may heighten tensions between both entities over player transfers. Contrastingly, FAI coaches took an opposing view and the majority indicated that the NL were introduced to create an environment that would assist in developing players capable of representing Irish international teams:

*"To give them a roadmap for their development so they can continue to improve and ultimately allow them to not only achieve whatever their potential may be but hopefully to become a professional player and also to assist and to create better players for our underage and senior international teams"* [FAIC3].

NL coaches provided a variety of responses that differed from that of schoolboy coaches and parents. NL coaches indicated that the two primary goals of their club were to produce players for first-team football; *"For me, as head of academy at my club, my sole interest would be to get players into the first team at our football club"* [NLC10], and to produce players for Irish international teams; *"I suppose it's getting better players to represent Ireland at international level"* [NLC4]. Moreover, NL coaches cited additional reasons for the implementation of the NL, including to create an environment for the best players to play with and against each other consistently, and to increase the standard of domestic football.

In respect to coaching standards in the NL, all parents reported that the coaching quality was overwhelmingly positive and were complimentary about how their children were developing as footballers since joining their respective academies. Parents were very happy with the coaching quality, citing it as, for example, *"second to none"* [P8], *"as good as it gets"* [P7] and "*top-level, really, really good*" [P3]. In particular, parents were encouraged by the high-quality and individualized approach to coaching. Typifying this, P9 commented:

*"I have to say that excellent is the word that I would use for this coach and his backroom team. It's innovative, they don't get bored, he has them doing the serious stuff and there's a novelty factor. Organisation and communication, it's all just planned. I don't think he does anything else! He overdoes his job, in a good way."*

In line with this, all NL coaches claimed that their coaching standards were high and were tailored toward player development. Moreover, NL coaches believed that their coaching was at a higher standard than was being provided in schoolboy football clubs. This may be a reflection of the coach education policies implemented by the FAI. To coach at the underage NL level, coaches must be qualified at UEFA B (under 14) and UEFA A (under 15–17) standards. Although NL coaches commented on how the standard of coaching at certain schoolboy clubs can be good, their impression was that the coaching quality at the schoolboy level is generally poor, mainly due to the reliance on parents/volunteer coaches; *"I just don't think the standards are there, I think that's the big one in that. Grassroots are fundamentally volunteers and you're relying on some volunteers taking things more seriously than others"* [NLC1]. This reliance on amateur coaches at the schoolboy level was perceived to be particularly detrimental to player development from a technical standpoint:

> *"I think it goes back to the coaching at the grassroots clubs for me. The big issue that I've had since managing at [National League Club] is the players' technical ability. They may be the better players at their grassroots clubs, and they've got good strengths and attributes, whether that be defending one to one or whatever it is, but I just find they're not technically comfortable" [NLC5].*

In response to the perceived poor coaching quality at the schoolboy level and the subsequent lack of technically skilled players progressing through the pathway, six NL coaches and two FAI Coaches cited the need for higher quality coaching to begin at earlier ages. Coaches explained how a lack of technically skilled players being developed in Ireland must be solved through earlier intervention by qualified coaches: *"I do believe that there needs to be more work done at a younger age, especially on the technical aspects. (…) It doesn't need to be as serious, but we should be focusing on it from 8, 9, 10 [years of age] in a fun technical way and really improving the technical aspects before they come into the National League"* [NLC9]. Supporting this, NLC10 stated; *"It just makes sense, the younger you can get them and work with them, then the more positive impact you can have on their career and the better player they will be by the time they get to National League football."*

Contrastingly, five schoolboy coaches were critical of certain coaching aspects in the NL, particularly regarding the styles of play. Schoolboy coaches explained how young players were being "overcoached" and the pressure to fit within tactical systems and set patterns of play was removing the freedom of expression in young players:

> *"it's a bit sterile and it takes a bit of the freedom away from the child and has them playing a certain way and the way that they have to play. Whereas, in grassroots football, there is a system, but there is a freedom there to go and express themselves. Its nearly overcoaching on systems and play"* [SC4]

However, five schoolboy coaches did also mention positive aspects of NL coaching, citing it as, for example, "more structured and more detailed" with "more qualified coaches."

## Alignment to Talent Development Principles

### Early Engagement

Seven NL coaches stated that the vast majority of players within their club have given up other sports to focus on football. Coaches felt players were deciding to invest in football due to a love for football and to give themselves the best opportunity to maximize their development:

> *''I think we have twenty players, and off of the top of my head, three of them play GAA (Gaelic Games) at the same time, other than that, that's it, so for seventeen of my players, their only sport is football. I think if we were at schoolboy, it wouldn't be. I think it's because its National League, they think 'this is a really good chance for me, and I love the environment and I want to give this everything"'* [NLC6].

Coaches also explained how numerous academy players have given up other sports and now use that spare time to undertake additional football training outside of the academy on non-training days:

> *"I know there are loads of players doing extra training and even getting one-to-one coaching on the days that we are not training. So, there are some that are putting just as much time into football as they are putting into school"* [NLC4].

This viewpoint was reiterated by several parents of NL academy players. Parents explained how their children enjoyed playing football and had ambitions to become professional players and, with this in mind, made the decision of their own accord to stop playing other sports:

> *"That's his choice [to give up other sports]. I think he's made that choice because he thinks he's a good footballer and he wants to see how far he can go, and he knows he needs to work"* [P5].

Unlike the academy system in countries such as England where players can enter the pathway at age six (Elite Player Performance Plan, 2011), the Irish academy system begins at 13. Participants in this study suggested that when academy players enter the pathway at 13, many decide to focus solely on football. This aligns with Cote's Developmental Model of Sport Participation, whereby at the end of primary school (around age 13), children have the opportunity to specialize in their chosen sport or continue in sport at a more recreational level (Côté and Vierimaa, 2014). However, all parents did reiterate that participation in other sports in their child's school environment was still compulsory, so no players had completely delaminated participation in other sports.

Six participants commented on the important role of football-specific free play in player development. Participants commented on how the lack of elite-level Irish players being produced over recent decades may be correlated to the lack of engagement in football free play by recent generations:

*"Probably, what our players need to do more of is be out in the garden or out with their friends kicking a ball around. That's probably why we as a nation were a lot more competitive 20 years ago; because players were getting so many hours in, not just with teams and coaches, but they were getting them in their back garden or school or whatever"* [NLC5].

Such suggestions mirror the recommendations of Zibung and Conzelmann (2013) and Sieghartsleitner et al. (2018), who proposed that the pathway should provide large amounts of football-specific activity but delivered in broad and diverse developmental formats. Supporting this, NLC2 reflected:

*"There's kids who come out of Brazil who don't get coached and they just play [football] constantly for hours and they just figure things out themselves, and all they play is football all day, all night. They're volleying the ball, they're doing beach football, everything is done with the football. What's the biggest single population that produces footballers in this world? It's the favelas in Brazil, but nobody [coaches] touches them until they're 14, but they play every day and they only play one sport every day."*

However, the vast majority of participants commented on how the football pathway and decisions surrounding player development policies needed to account for the uniqueness of the Irish cultural context in which the pathway exists. Despite the perceived benefits of early engagement in football, participants cited how the GAA is a unique, but dominant part of Irish culture that goes beyond sport and heavily influences both sporting and societal contexts; *"Gaelic is so predominant, it's so patriotic, it's more than just which sport do you play. (. . . ) Gaelic is just intertwined with social life"* [P4]. Moreover, participants commented on how implementing a player development system similar to those adopted in other successful European football nations would be very difficult, as culturally *"football in Ireland is competing with the GAA"* [P1]. From a player development perspective, such cultural ties with the GAA were seen as a barrier long-term:

*"I have two lads [in my team] who are from here but play down with me in [Names Location] and their school is just hurling. So, their chance of getting football in school is nil. If you took a football onto one of their hurling pitches, you'd get expelled I'd say, it's that serious. So, this is where the problem comes in"* [NLC3].

*"We are unique in terms of some countries because in some countries, all they have is football, whereas we've got Gaelic and Hurling. There's a lot of young people living in country villages and stuff like that and you play for your [GAA] team. Sometimes we do want them to play football, but tradition, values and beliefs come in the way and I think as a society in Ireland, that's our stumbling block"* [NLC8].

Despite this, all participants commented on the benefits of playing other sports throughout childhood and into early adolescence, and no participants expressed a belief that children should focus solely on one sport throughout these formative years. Specifically, twenty-six participants cited the biopsychosocial benefits of playing multiple sports as an important factor in childhood development. In addition, twenty-five were strong advocates of the need for children to sample other sports throughout childhood before they reach their teenage years:

*"I think at seven, eight, nine, ten, eleven [years old] and before they go into the pathway at 13 or 14 for the League of Ireland, and it's the same with the GAA; they've gone 13 as well, I think up to eleven or twelve you should be encouraging it [playing other sports]"* [SC8].

Eleven participants also commented on how they felt that players should be encouraged to recreationally participate in other sports on their non-football days outside of the academy:

*"I do say to them, especially when we're in the off-season, pick up golf, pick up tennis, basketball with your friends, I think all of that is important to do and we do encourage them to do that as long as it doesn't conflict with what we do. We do encourage them. It is important to do other sports"* [NLC6].

## Biological Maturation

Participants were concerned that a selection bias existed throughout the NL in favor of early maturing players. The vast majority of parents and schoolboy coaches explained how they felt that player identification and release/retention was based upon physical attributes and the early maturing players were being preferentially selected into and retained within NL academies:

*"There are some lads and you just look at them and think 'how is he 14?'. He gets picked because of that. Physically, he may be strong, but technically he may not be that strong. All these guys get lumped into one bucket based on age and the consequence of that is that what coaches look for in that bracket is physicality rather than technical ability"* [P6].

Such a selection bias in favor of early maturing athletes is not uncommon and has been observed within football academies outside of Ireland (i.e., Hill et al., 2020). Nine participants felt that later maturing players were being overlooked in selection for NL academies and were subsequently "falling through the gaps." Additionally, four participants believed that NL players should be categorized by physical size rather than chronological age. Moreover, ten participants believed that later maturing players were being hindered by the misalignment of age structures within the NL. The age structures of the NL currently run bi-annually from under 15 onwards (i.e., under 15, 17, 19) instead of annually (i.e., under 15–16–17). Participants believed this to be particularly disadvantageous to the later maturing players within the academy pathway, as NLC9 explained:

*"Probably one of the biggest issues that you find, especially going from 15 to 17, is that late developers need to be catered for. That's something I'm seeing at the moment in our under 15s; we have a mixture of sizes and stuff even at this age, and they're all born in the same year. You could have an exceptional under 15, but physically he might be a late developer and he steps up to under 17 level and it's a huge challenge physically and there is a year gap there as well,*

*so not only is he dealing with the physical gap of his own age, but also the physical gap of players the year older."*

## Systematic Barriers to Player Development

The majority of NL coaches, schoolboy coaches and FAI coaches were all critical of the lack of facilities in the NL, citing it as the biggest organizational barrier to player development in Ireland. NL coaches were particularly critical of the lack of training and match facilities, and expressed the need for intervention across the country:

*"We massively struggle with facilities. I don't know if you've been to [Names location where matches are played], but that needs to be updated to kick players on. I think that would be the case in a lot of clubs around the country. Then Gyms, proper AstroTurf pitches, better quality surfaces to play on. For me, that's a big thing"* [NLC5].

Such concerns were reiterated among FAI coaches:

*"When you look at the National League clubs…I can tell you we've got schoolboy clubs in this county that have their own clubhouse, they've got two all-weather pitches, and they cater for an academy on a Saturday morning of about 400 kids. Then we've got two National League clubs… they don't have a training ground that they own, they don't have a pitch that they own"* [FAIC2].

Schoolboy coaches also criticized the standard and accessibility of facilities in the NL. Schoolboy coaches believed that the standard of facilities in the NL are no better than schoolboy clubs and commented on how many NL clubs were renting training facilities from third parties:

*"You go to [National League Club] and it's like going back in the dark ages, they don't have their own facilities and they train in a public park, it's not even a step up. If you look across the whole of the National League, you could probably look at two or three clubs that have really good facilities. Like [National League Club] don't have any training facilities, they go around and use AstroTurf pitches all around. Really, from a set-up perspective, there is nothing there to entice children to say, 'this is where I want to be' (…) facilities-wise, it's extremely poor"* [SC4].

Ninety percent of NL clubs share facilities with another club/external source, and when taken in comparison to nations with similar demographics, access to facilities in Ireland is substantially lower (UEFA, 2020). For example, each professional Danish club has nearly double the amount of full-sized grass pitches and has nearly three times the number of artificial pitches than each Irish NL club (UEFA, 2020). Additionally, all NL coaches cited the lack of a full-time football industry in Ireland as a major systematic flaw in the player development system. NL coaches expressed frustrations over the lack of full-time coaching positions within NL academies and how they were expected to manage the development of the highest potential young footballers in Ireland whilst also trying to balance full-time jobs elsewhere:

*"You will find most of the coaches, even though they're highly qualified, they're part-time! Like I work, I finished work today at 2 pm. I've been in since 6 am and I finished at 2, and the nights I train I come home and have something to eat and then I'm on the road again at half 5 and I probably don't get home until 10 that night"* [NLC3].

*"People are always saying we should have academies like in England, like Liverpool's academy. Well, there's no full-time staff, so who coaches these kids all day long? The fact [is] that we don't even have an industry"* [NLC6].

On average, each European premier division club employs 5–7 full-time academy coaches who are exclusively dedicated to youth development (UEFA, 2020). Across all clubs ($n = 25$) and all age cohorts (under 14–19) in the underage NL, there are a total of 6 full-time staff, none of whom are exclusively dedicated to coaching (League of Ireland and FAI Academy Development Manager, personal communication, 2021). In this regard, Ireland is ranked within the lowest threshold in Europe for full-time staff dedicated to organization/logistics, medicine, education, coaching, and scouting/analysis (UEFA, 2020).

In line with this, ten participants were also critical of the lack of financial investment in Irish football. To bridge the gap to other European countries at a senior international level, and to ultimately develop a larger number of high-quality players, participants expressed the need for large scale financial investment in Irish football, as exemplified by FAIC3:

*"I think if we look at the National League clubs, even the grassroots clubs, obviously the FAI programmes; the more you put in, the more you get out. And the reality of it is if you look at any of our programmes and you question 'what do we want to get out of this?', if someone says, 'we want f**cking our senior national team to be qualifying for major European and world finals off the crop of players we have now', you need to put more money in! That's the reality of it. For what the FAI is putting in, and listen, I'm FAI through and through I'll support them until the day I die, but the place is obviously in the sh*t at the moment, so what we're putting in is not getting us to world cup finals in 15 years' time, not a chance! Unless every other country stops doing what they're doing, we ain't getting nowhere!"*

## Lack of Appropriate Challenge

Participants expressed concerns that the NL were failing to provide appropriate levels of challenge for young players. The importance of providing appropriate levels of challenge in talent development has been emphasized in literature elsewhere (i.e., Collins and MacNamara, 2012; Collins et al., 2016). Specifically, in this Irish football context, fifteen participants from across all stakeholder groups expressed a view that there were large variations between the standard of teams within the NL, characterized by one-sided score-lines and uncompetitive matches. As a consequence, it was believed that players from the stronger teams in the NL were not being challenged appropriately, and the players from teams of lesser quality were being exposed to an environment that was not suited to their needs at that particular stage of their development. Typifying this, SC4 commented:

*"I think if we look at the National League, it's probably not challenging for about three or four clubs who are operating at a totally different level from a National League perspective. They don't get challenged on a week-to-week basis. Some of the children, if they stayed in their local leagues, would have more of a challenge than when they go and play some of the other clubs and win 5, 6, 7, 8–0; that's not a challenge and neither party is learning in that regard."*

NL coaches also expressed concerns that players were not being challenged frequently enough due to a lack of coaching contact hours and matches. A player aged 12–16 in a category 1 UK football academy gets 12–16 coaching contact hours a week (Read et al., 2016). The consensus among coaches in this study was that players aged 13–15 in a NL academy get 3–6 h per week. This lack of contact hours was considered particularly disadvantageous to player development in Ireland, as NLC6 explained:

*"I think we don't do enough. The contact hours are nowhere near enough. It's crazy to think what everyone else is doing in Europe and players are developing and we're not developing players at the moment in my opinion. I think we don't have enough contact."*

### An Emphasis on Short-Term Success

Seventeen participants expressed concerns that an emphasis was placed on short-term success over long-term development, opposing a key principle of talent development outlined by Martindale et al. (2007). The majority of parents believed that there was an over-emphasis on winning matches throughout the NL which took priority over player development, as P6 reiterated:

*"You'd like it all not to be so results orientated. You'd love there to be metrics to judge teams based on how they develop players and not how many games that they win. The table is still a table based on how many points a team gets, there's no other table to show other metrics that are important. In our league, it's all about goals, winning and points, but that means then that all the actions that we do are trying to reach them goals."*

This feeling was reciprocated by several NL coaches:

*"There is an emphasis on winning and some teams and some coaches will win at all costs (…) There's always pressure to win matches. I think in different clubs there's different ethos and value put on winning matches, and sometimes in the National League, it's winning ahead of development"* [NLC4].

## IMPLICATIONS FOR PRACTICE

Using an extensive sample of stakeholders engaged within Irish underage football, the results of our analyses highlight the lack of horizontal and vertical coherence across the Irish football pathway. This incoherent player pathway and the disjointed relationships between stakeholders were suggested as a significant barrier to long-term player development. Stakeholders appeared to understand talent development principles, but this has not led to the consistent implementation of these principles in the development of young Irish players.

Vertical coherence in Irish football should lead to a symbiotic working relationship between the SFAI, NL clubs, and the FAI. Previous research suggests that football organizations should place value in creating vertically integrated processes of talent development (Webb et al., 2016; Taylor and Collins, 2021). However, vertical integration throughout the pathway in Ireland does not appear to exist. All stakeholders cited how a fractious relationship existed between schoolboy football clubs and NL academies, characterized by conflicts over player transfers, financial disputes and dissonance over the control of player development. This lack of vertical integration was perceived to be intertwined with the poor historical relationship between the FAI and SFAI. The disconnect between the SFAI (an affiliate of the FAI) and the FAI regarding what is best for player development appears a major obstacle for player development in Ireland. Having NGB affiliates self-governing and operating independently from the NGB is not best practice in player development (Webb et al., 2016), particularly when individual leagues within the affiliate operate independently from each other. This lack of vertical coherence throughout the pathway is considered to be an obstacle in long-term player development (Webb et al., 2016; Taylor and Collins, 2021). Indeed, it has been stated that effective talent development environments are distinguished by the existence of a strong organizational structure throughout the pathway (Henriksen et al., 2010a,b). The evident lack of integration between schoolboy football clubs and NL academies was exemplified by the lack of shared understanding regarding coaching and the purpose of the NL academies, and ultimately, the purpose of the player pathway. In theory, a shared understanding of player development in Ireland would entail schoolboy clubs working closely with NL clubs to facilitate the smooth transition of players from the schoolboy level into the academy environment. Whilst this shared understanding and vertically coherent player development system ceases to exist, the player development pathway within Irish football is unlikely to be optimized (Mills et al., 2014a).

A lack of horizontal coherence was also apparent at the NL level, most notably in the relationships between coaches and parents. The existence of horizontal coherence in an academy context should see academy coaches and parents working with each other and with the player in an agreed fashion to optimize the player development experience (Taylor and Collins, 2021). However, the academy pathway was characterized by poor communication and a lack of role clarity between coaches and parents. Parents expressed concerns over the lack of regular and comprehensive communication from coaches, which is a common concern within football academies elsewhere (Harwood et al., 2010; Clarke and Harwood, 2014). On the other hand, coaches explained how parents can often interfere with coaching practices, most notably by providing inappropriate and contradictory coaching advice (in line with Mills et al., 2012). Such findings indicate that parents often appear unaware of their role (Côté, 1999) and suggest the need for academies to implement regular and comprehensive parent education workshops (Clarke and Harwood, 2014; Newport et al., 2020). Academies should work with parents to build more positive working relationships tailored toward optimizing

their influential role as "football parents" (cf. Mills et al., 2012).

Multiple stakeholders raised concerns over the youth to senior transition within the player pathway. Participants explained how academy and senior team operations are not aligned and how the transition from academy to first-team football is too great for many players. Significantly, the youth to senior athlete transition has traditionally been noted as the most challenging transition in an athlete's career (Stambulova et al., 2009) and dichotomy between the two stages of the pathway is likely to have detrimental repercussions for successful player development (Mills et al., 2014b). In a NL context, it appears that youth and senior team operations and transitions are not well-integrated.

Despite the lack of stakeholder coherence across and within the pathway, talent development principles between the stakeholders appear well-understood. For instance, participants highlighted the need to provide an appropriate and individualized challenge for players throughout the pathway (Collins and MacNamara, 2012) and noted the need to emphasize long-term development over short-term success (Martindale et al., 2007). Despite this, as is the case in many talent development pathways (Pankhurst et al., 2013), the implementation of these talent development principles in an applied context does not appear to exist. In this respect, participants were critical of the academy system and explained how players were not being provided with appropriate or individualized levels of challenge. Stakeholders perceived there to be large variations in the quality of academy teams, characterized by uncompetitive matches and uneven score-lines. Moreover, there was a common perception among stakeholders that a selection bias existed in favor of early maturing players and that this may have a detrimental impact on long-term player development (cf. Cumming et al., 2018).

In line with the key principles of effective talent development environments (Martindale et al., 2007), participants were critical of the emphasis that was placed upon winning matches at the academy level. The use of short-term success as a marker of effectiveness within the NL appears short-sighted, especially given that the system is suggested to specifically focus on producing Irish internationals and senior first-team club players. Fundamentally, football academies exist to produce individual players, not successful academy teams (Mills et al., 2012). Without a change in emphasis on winning academy football matches, problems will continue to exist in player selection, coaching, and the subsequent experiences of the academy players (Martindale et al., 2007).

Participants described how they believed an early engagement in football to be optimal for player development. They also emphasized the importance of devoting the majority of childhood activity to football to maximize development before entering an academy at age 13. The importance of experiencing large amounts of football-specific learning activities during childhood has been emphasized in the literature elsewhere (Ford et al., 2009; Ford and Williams, 2012; Sieghartsleitner et al., 2018; Zibung and Conzelmann, 2013). However, participants believed that this should not be at the expense of participation in other childhood sporting activities particularly up to 12 or 13 years of age. Crucially, participants acknowledged the unique context in which the Irish player pathway exists and the cultural dominance of the GAA. Indeed, culture has an over-arching emphasis on the development of talent (Martindale et al., 2007; Henriksen et al., 2010a). In this respect, implementing a player development system similar to those seen in other football nations (i.e., Elite Player Performance Plan, 2011) may not be viable nor appropriate in an Irish-specific context as it may conflict with cultural and societal norms.

The question for Irish football is whether Ireland can consistently produce players capable of competing at the highest level of international football when young players develop in a cultural climate where football exposure time is limited due to competitive participation in multiple sports until mid-late teens. The benefits of this approach in football player development remain unclear (cf. Sweeney et al., 2021). Between 2011 and 2020, out of all the 200 FIFA member associations, Ireland had the most players aged under 18 transferred to professional clubs abroad, most consistently to UK-based clubs (FIFA, 2021a). This is likely a reflection of the standard of the domestic league in Ireland during that time period (ranked between 31st and 43rd out of a maximum of 55 European leagues; UEFA, 2021). It was in these UK-based academies where the highest potential Irish players continued their development after leaving Ireland. However, once the UK formally left the EU during Brexit, the exemption that allows European clubs to sign European players aged under 18 no longer applied to UK-based clubs, making Irish clubs responsible for developing players up to 18 years of age. With a lack of vertical and horizontal stakeholder coherence, coinciding with a lack of full-time staff, facilities, financial investment, and football exposure time, Irish football is arguably faced with its biggest ever challenge to develop players capable of competing against its international counterparts. Ireland's senior international men's team is currently ranked 51st out of 210 nations, compared to a ranking of 28th only 10 years ago (FIFA, 2021b). From the start of the 2021/22 season, there were 22 Irish players registered with an English Premier League first team (The Irish Times, 2021), with no capped Irish players registered with a first team in any other top-five ranked European domestic football league (La Liga, Serie A, Ligue 1, Bundesliga; UEFA, 2021).

## Limitations

Given that the focus of this research was on the Irish football player pathway, results and their implications are specifically limited to an Irish football context. In this respect, findings may not apply to non-Irish contexts or alternative sporting pathways. It is up to the reader to consider the transferability of these findings to their specific sporting and cultural context. However, given the recent restructure of the Irish football player pathway and the introduction of the newly formed underage NL, it was crucial from both an organizational and practical perspective to explore stakeholder perceptions of the player development experience. This was the first research of its kind to comprehensively analyse the Irish football player pathway from the perspectives of the key stakeholders. Given the extensive ($n = 31$) and contemporary participant sample of this research, along with the nature of data collection (one-to-one interviews to facilitate an in-depth and individualized investigation), we

believe these findings to be valid and reliable. In this regard, results can be utilized to guide decisions on future player and coach development policies within the FAI. An additional limitation of this research was that it focused on the Irish player pathway for male players only. Although some participants who were interviewed in this research study were female, it is clear that the research focus lacks gender diversity.

## FUTURE DIRECTIONS

We have examined the experiences and perceptions of the key stakeholders invested in the player pathway. As a next step, it is important to consider the experiences and viewpoints of the young Irish players engaged in the pathway themselves. To date, young players have been absent from the discussion. To optimize the pathway and player development policies, discussions must take place with the players engaged within the academy pathway, across multiple Irish football academies and age cohorts. It would be of particular value to identify the players' perceptions of the quality of their talent development environment and optimal developmental practices. It is also important to examine the players' perceptions of their relationships with the different stakeholders involved in the development process. The additional benefit of this approach is clear, and we will seek to examine these perceptions in our upcoming research agenda.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available upon request to the corresponding author.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Dublin City University Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

LS, DH, and ÁM contributed to the conception and design of the study. LS performed the data collection and data analysis, with ÁM reviewing the analysis. LS wrote the initial manuscript, with DH and ÁM contributing to manuscript revisions. All authors read and approved the submitted manuscript.

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## REFERENCES

*Football Association of Ireland Player Development Plan* (2015).

Aalberg, R. R., and Sæther, S. A. (2016). The talent development environment in a norwegian top-level football club. *Sport Sci. Rev.* 25, 159–182. doi: 10.1515/ssr-2016-0009

Abraham, A., and Collins, D. (2011). Taking the next step: ways forward for coaching science. *Quest* 63, 366–384. doi: 10.1080/00336297.2011.10483687

Braun, V., and Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qual. Res. Sport. Exerc. Health* 11, 589–597. doi: 10.1080/2159676X.2019.1628806

Braun, V., and Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qual. Res. Psychol.* 18, 328–352. doi: 10.1080/14780887.2020.1769238

Bryant, A. (2009). Grounded theory and pragmatism : the curious case of anselm strauss 1 . issues and aspects of grounded theory 1. 1 the emergence and growth of GTM It is widely acknowledged that one of the strengths of. *Forum Qual. Soc. Res.* 10, 1–31. Available online at: ///Users/macbook/Downloads/Grounded_Theory_and_Pragmatism_The_Curious_Case_of.pdf

Byrne, D. (2021). A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Qual. Quant.* 16, 227–235. doi: 10.1007/s11135-021-01182-y

Clarke, N., and Harwood, C. (2014). Parenting experiences in elite youth football: a phenomeno- logical study. *Psychol. Sport Exerc.* 15, 528–537. doi: 10.1016/j.psychsport.2014.05.004

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

Collins, D. J., Macnamara, A., 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

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

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

Curran, O., MacNamara, Á., and Passmore, D. (2021). Singing off the same hymn sheet? Examining coherence in a talent development pathway (part 1). *J. Sports Sci.* 39, 1709–1716. doi: 10.1080/02640414.2021.1896456

Cushion, C., Ford, P. R., and Williams, A. M. (2012). Coach behaviours and practice structures in youth soccer: implications for talent development. *J. Sports Sci.* 30, 1631–1641. doi: 10.1080/02640414.2012.721930

Elite Player Performance Plan (2011). *A Document Prepared by the English Premier League*. Elite Player Performance Plan. Available online at: https://www.goalreports.com/EPLPlan.pdf

FIFA (2021a). *Ten Years of International Transfers: A Report on International Football Transfers Worldwide 2011–2020*. FIFA. Available online at: https://sports.tj/wp-content/uploads/2021/09/fifa-ten-years-international-transfers-report.pdf

FIFA (2021b). *Republic of Ireland*. FIFA. Available online at: https://www.fifa.com/fifa-world-ranking/IRL

Flatgård, G., Larsen, C. H., and Sæther, S. A. (2020). Talent development environment in a professional football club in Norway. *Scand. J. Sport Exerc. Psychol.* 2, 8–15. doi: 10.7146/sjsep.v2i0.114470

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

Ford, P. R., Bordonau, J. L. D., Bonanno, D., Tavares, J., Groenendijk, C., Fink, C., et al. (2020). A survey of talent identification and development processes in the youth academies of professional soccer clubs from around the world. *J. Sports Sci.* 38, 1269–1278. doi: 10.1080/02640414.2020.1752440

Ford, P. R., Ward, P., Hodges, N. J., and Mark Williams, A. (2009). The role of deliberate practice and play in career progression in sport: the early

engagement hypothesis. *High Abil. Stud.* 20, 65–75. doi: 10.1080/13598130902860721

Giacobbi, P., 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

Gould, D., Dieffenbach, K., and Moffett, A. (2002). Psychological characteristics and their development in olympic champions. *J. Appl. Sport Psychol.* 14, 172–204. doi: 10.1080/10413200290103482

Gould, D., Lauer, L., Rolo, C., Jannes, C., and Pennisi, N. (2006). Understanding the role parents play in tennis success: a national survey of junior tennis coaches. *Br. J. Sports Med.* 40, 632–636. doi: 10.1136/bjsm.2005.024927

Gray, L. M., Wong-Wylie, G., Rempel, G. R., and Cook, K. (2020). Expanding qualitative research interviewing strategies: zoom video communications. *Qual. Rep.* 25, 1292–1301. doi: 10.46743/2160-3715/2020.4212

Harwood, C., Drew, A., and Knight, C. J. (2010). Parental stressors in professional youth football academies: a qualitative investigation of specialising stage parents. *Qual. Res. Sport Exerc.* 2, 39–55. doi: 10.1080/19398440903510152

Henriksen, K., Stambulova, N., and Roessler, K. K. (2010a). Holistic approach to athletic talent development environments: a successful sailing milieu. *Psychol. Sport Exerc.* 11, 212–222. doi: 10.1016/j.psychsport.2009.10.005

Henriksen, K., Stambulova, N., and Roessler, K. K. (2010b). Successful talent development in track and field: considering the role of environment. *Scand. J. Med. Sci. Sport.* 20, 122–132. doi: 10.1111/j.1600-0838.2010.01187.x

Hill, M., Scott, S., McGee, D., and Cumming, S. P. (2020). Are relative age and biological ages associated with coaches' evaluations of match performance in male academy soccer players? *Int. J. Sport. Sci. Coach.* doi: 10.1177/1747954120966886

Ivarsson, A., Stenling, A., Fallby, J., Johnson, U., Borg, E., and Johansson, G. (2015). The predictive ability of the talent development environment on youth elite football players' well-being: a person-centered approach. *Psychol. Sport Exerc.* 16, 15–23. doi: 10.1016/j.psychsport.2014.09.006

Larsen, C., Alfermann, D., Henriksen, K., and Christensen, M. K. (2013). Successful talent development in soccer: the characteristics of the environment. *Sport. Exerc. Perform. Psychol.* 2, 190–206. doi: 10.1037/a0031958

Larsen, C. H., Storm, L. K., Sæther, S. A., Pyrdol, N., and Henriksen, K. (2020). A world class academy in professional football: *Scand. J. Sport Exerc. Psychol.* 2, 33–43. doi: 10.7146/sjsep.v2i0.119746

Lund, S., and Söderström, T. (2017). To see or not to see: talent identification in the swedish football association. *Sociol. Sport J.* 34, 1–27. doi: 10.1123/ssj.2016-0144

Martindale, R. J., Collins, D., and Daubney, J. (2005). Talent development: a guide for practice and research within sport. *Quest* 57, 353–375. doi: 10.1080/00336297.2005.10491862

Martindale, R. J. J., Collins, D., and Abraham, A. (2007). Effective talent development: the elite coach perspective in UK sport. *J. Appl. Sport Psychol.* 19, 187–206. doi: 10.1080/10413200701188944

Mills, A., Butt, J., Maynard, I., and Harwood, C. (2012). Identifying factors perceived to influence the development of elite youth football academy players. *J. Sports Sci.* 30, 1593–1604. doi: 10.1080/02640414.2012.710753

Mills, A., Butt, J., Maynard, I., and Harwood, C. (2014a). Examining the development environments of elite English football academies: the players' perspective. *Int. J. Sport. Sci. Coach.* 9, 1457–1472. doi: 10.1260/1747-9541.9.6.1457

Mills, A., Butt, J., Maynard, I., and Harwood, C. (2014b). Toward an understanding of optimal development environments within elite english soccer academies. *Sport Psychol.* 28, 137–150. doi: 10.1123/tsp.2013-0018

Newport, R., Knight, C. J., and Love, T. (2020). The youth football journey: parents' experiences and recommendations for support. *Qual. Res. Sport. Exerc. Health* 11, 589–597. doi: 10.1080/2159676X.2020.1833966

O'Connor, D., Larkin, P., and Williams, A. M. (2018). Observations of youth football training: how do coaches structure training sessions for player development? *J. Sports Sci.* 36, 39–47. doi: 10.1080/02640414.2016.1277034

Pankhurst, A., and Collins, D. (2013). Talent identification and development: the need for coherence between research, system, and process. *Quest* 65, 83–97. doi: 10.1080/00336297.2012.727374

Pankhurst, A., Collins, D., and MacNamara, Á. (2013). Talent development: linking the stakeholders to the process. *J. Sports Sci.* 31, 370–380. doi: 10.1080/02640414.2012.733821

Read, P. J., Oliver, J. L., De Ste Croix, M. B. A., Myer, G. D., and Lloyd, R. S. (2016). The scientific foundations and associated injury risks of early soccer specialisation. *J. Sports Sci.* 34, 2295–2302. doi: 10.1080/02640414.2016.1173221

Relvas, H., Littlewood, M., Nesti, M., Gilbourne, D., and Richardson, D. (2010). Organizational structures and working practices in elite European professional football clubs: understanding the relationship between youth and professional domains. *Eur. Sport Manag. Q.* 10, 165–187. doi: 10.1080/16184740903559891

Sieghartsleitner, R., Zuber, C., Zibung, M., and Conzelmann, A. (2018). "The early specialised bird catches the worm!" - a specialised sampling model in the development of football talents. *Front. Psychol.* 9:188. doi: 10.3389/fpsyg.2018.00188

Smith, M., and Cushion, C. J. (2006). An investigation of the in-game behaviours of professional, top-level youth soccer coaches. *J. Sports Sci.* 24, 355–366. doi: 10.1080/02640410500131944

Stambulova, N., Alfermann, D., Statler, T., and Cote, J. (2009). ISSP position stand: career development and transitions of athletes. *IJSEP* 7, 395–412. doi: 10.1080/1612197X.2009.9671916

Sweeney, L., Horan, D., and MacNamara, Á. (2021). Premature professionalisation or early engagement? Examining practise in football player pathways. *Front. Sport. Act. Liv.* 3:660167. doi: 10.3389/fspor.2021.660167

Taylor, J., and Collins, D. (2021). Getting in the way: investigating barriers to optimizing talent development experience. *J. Expert.* 4, 315–332. Available online at: https://journalofexpertise.org/articles/volume4_issue3/JoE_4_3_Taylor_Collins.pdf

The Irish Times (2021). *Irish Involvement Likely to be Sparse in New Premier League Season.* The Irish Times. Available online at: https://www.irishtimes.com/sport/soccer/irish-involvement-likely-to-be-sparse-in-new-premier-league-season-1.4646194

UEFA (2020). *Training Facilities, and Youth Investment Landscape*. UEFA (2020).

UEFA (2021). *Country Coefficients.* Available online at: https://www.uefa.com/nationalassociations/uefarankings/country/#/yr/2022.

Webb, V., Collins, D., and Cruickshank, A. (2016). Aligning the talent pathway: exploring the role and mechanisms of coherence in development. *J. Sports Sci.* 34, 1799–1807. doi: 10.1080/02640414.2016.1139162

Williams, A. M., Ford, P. R., 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

Wolfenden, L. E., and Holt, N. L. (2005). Talent development in elite junior tennis: perceptions of players, parents, and coaches. *J. Appl. Sport Psychol.* 17, 108–126. doi: 10.1080/10413200590932416

Zibung, M., and Conzelmann, A. (2013). The role of specialisation in the promotion of young football talents: a person-oriented study. *Eur. J. Sport Sci.* 13, 452–460. doi: 10.1080/17461391.2012.749947

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# Staying in or Dropping Out of Elite Women's Football—Factors of Importance

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The average age of elite women footballers in Norway is 22.7 years, significantly lower than that of elite male footballers in Norway (26.5). This study examines the factors leading to elite female footballers ending their careers at a relatively young age, and those factors influencing other female elite players to continue. Semi-structured interviews were conducted with five female elite players who had ended their career at the age of 19–24, and four who were still active (age 26–31). Based on the age of the informants who had ended their career and the informants who were still active, this study defines "young age" as <25years of age. The female elite players experiences were analyzed and discussed in relation to earlier research. The results of the study show that the same factors affecting the early end of a career, also had an impact on continuing the career in the Norwegian top league, beyond the average age. A low level of internal and external motivation, poor financial circumstances, high stress load, long injury breaks, lack of playing time and other priorities, are all factors leading elite players to end their football careers at a young age. These factors are increasingly being addressed in relation to still active elite players, and this has an impact on the length of their playing career. Like earlier research, this study indicates that the emergence of Norwegian women's football in recent years has helped to improve conditions for being female elite players in the professional leagues in Norway.

**Keywords: female, soccer, elite level, drop out, career**

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## INTRODUCTION

In 1976, women's football was officially approved as a formal sport by the Norwegian Football Federation (NFF), and for the first time women in Norway got their own official leagues and tournaments. In the years that followed interest spread among girls and women of all ages throughout the country (Goksøyr and Olstad, 2002). By 2019 there were 113,000 active girl and women football players in Norway, and NFF was actively working to promote girls' and women's football, and it has made it a priority area also for 2020–2023 (NFF, 2021).

In 2019, the NFF expressed concern about the low average age of players in the women's Norwegian top league. According to *Tinghefte* (the report from NFF's annual assembly) in 2019, players in *Toppserien* (the Norwegian top league of women's football in Norway) had an average age of 22.7 years. This low average age was clarified further by UEFA's (Union of European Football Associations) survey, showing that Norway has a smaller number of active adult players than many other countries in UEFA (NFF, 2021). It is reasonable to argue that there could be an association between the small number of active female players, and the low average age of female

elite players, because of early drop out. In comparison, a cross-sectional survey from 2019 showed that the average age of male players in *Eliteserien* (the Norwegian top league of men's football in Norway) was 26.5 years, which means that men had a significantly longer career than women. The difference at almost 4 years between men and woman dropping out of elite football, is a source of concern according to the relatively few years players participate at the top level. On the basis of these findings, the leadership of NFF is concerned that the low average age may impact Norway's competitiveness in international women's football (NFF, 2021). This concern is supported by the study of Barreira (2016): "Age of Peak Performance of Elite Women's Soccer Players", where the result showed that national teams with higher average age on their players, performed better in the London 2012 Olympic Games, than the teams with lower average age.

The theoretical framework for this study lies within hegemonic masculinity (Connell and Messerschmidt, 2005). Kaelberer (2019) argue that football represents a social sphere for the expression of hegemonic masculinity, and suggest that football continues to be described as one of the last male preserves, in which men can act out their masculinity. In this sense, football offers a space for the performance of hegemonic masculinity. Hegemonic masculinity is a relational concept that is produced as the dominant concept that legitimates inequitable hierarchical relations between men and women (Drummond, 2003; Connell and Messerschmidt, 2005; Tucker and Govender, 2017. The universal characteristics of hegemonic masculinities are related to strength, speed, muscularity, and competitiveness as being produced as dominant—characteristics that are central in football, and giving men more acknowledgment and better conditions for staying in elite level football. Female elite players players on the other hand, get poorer conditions for doing elite sport in relation to lack of financial security—leading female to prioritize education and work outside elite football play. Studies have shown that this stress may lead to drop out among female elite players (McCormack, 2011; Gammelsæter and Solenes, 2013; Brandt-Hansen and Ottesen, 2017; Grygorowicz et al., 2019; Wang, 2019; McGreary et al., 2021). As researchers, we position ourselves within a position that promote gender equality and diversity (Drummond, 2003; Paechter, 2019), argue that there is a need to challenge the hegemonic nature of masculinized PA in every arena—also in football. According to (Paechter, 2019) understanding the gender regime of any setting gives insight into power relations about how specific groups—such as female elite football players, place and position themselves.

A few earlier studies have addressed the factors affecting the career of female elite players. Brandt-Hansen et al. (2014), in their study of Danish women footballers, found that lack of motivation, injury and shortage of time were the three principal reasons for dropping out of elite football. Likewise, lack of motivation was seen by current elite players as the most likely reason for their dropping out in the future, while the opportunity to constantly improve, the joy of performing, and finding football fun and pleasurable were given as reasons for carrying on playing. External motivation, according to Gagné and Deci (2005), refers to behavior driven by the wish to achieve rewards or avoid punishment, while internal motivation arises when behavior and participation are governed by joy, interest, or excitement relating to the activity itself. Both internal and external motivation can be presumed to play a part in the ending or continuance of playing elite football. In a survey conducted by NRK in collaboration with SVT and YLE, large financial differences between male and female elite players were revealed (Lie, 2017). The figures show that a man on the national football team earns an average of 640,000 Euro more a year than a woman on the national football team. Of 13 factors potentially playing a part in motivation to play at an elite level, "money and other material benefits" showed itself to have least significance for elite players (Brandt-Hansen et al., 2014). In addition, "making money from the sport" came out last when asked what goals and ambitions they had with football. According to Brandt-Hansen et al. (2014), this is not unexpected as the possibility of earning money and living as a full-time professional is limited in Danish women's football. Brandt-Hansen and Ottesen (2017), confirmed this in a later study, in that of the 102 elite female footballers who participated in their study, only 2% had a full professional contract. The remainder were dependent on income from outside work, study grants or help from their family. Given that only a small minority had a full-time contract, Brandt-Hansen and Ottesen (2017) suggest that women's football in Denmark is seen as an amateur elite sport, lacking opportunities to pursue it full-time. In the same study, Brandt-Hansen and Ottesen found that lack of time and inadequacy of financial resources were given as factors among women footballers ending their careers.

Both Wang (2019) and Grygorowicz et al. (2019) argue that the overall stress burden on female footballers is unsustainable, emphasizing the importance of freeing up time so that players have the opportunity to train and get sufficient rest, while being able to maintain a social life outside football. In a study by McGreary et al. (2021), elite female players found it challenging to balance education, work and football, as well as having a social life. The studies of McCormack (2011), Gammelsæter and Solenes (2013) and Brandt-Hansen and Ottesen (2017) each describe the importance of education for female football players. Although sport is an unpredictable career for all involved, elite male footballers are better able to secure themselves financially via their career, whilst female players will have little to fall back on. Brandt-Hansen and Ottesen (2017), found, in their study, that another significant factor in ending a football career was the desire to establish a family and to have children, whilst Grygorowicz et al. (2019), found that injuries were a reason for drop out among female players. Sandon et al. (2015) found that women footballers carry a greater risk of cruciate ligament injuries, and that these occur at a younger age in women than in men. The study also found that fewer women than men return to football after such injuries.

In Brandt-Hansen et al.'s (2014) study, the results showed that there was a significant difference between Danish elite players who had played for the national team, and those who had not, in the extent to which they felt trusted and supported by their coach

and club. Those elite players who had experience in none of the under-16, 18, and 21 national teams nor the senior team, felt, to a greater degree, that a lack of support from coach and club was a factor stopping them for playing at elite level (Brandt-Hansen et al., 2014). Johansen (2016) also found that players who had most playing time and were regularly in the starting eleven, were happy with their coach, whilst those who often served as reserves were less so. Furthermore, women more than men thought it was important that the trainer offered them recognition, and that they felt seen.

Despite some research in this field, this earlier research suggests that the factors leading elite female football players to end or to continue their careers has been an understudied field, both in Norway and internationally. Few studies have investigated the early ending of the careers of elite female footballers.

Despite some research at this field, previous researches suggests that the factors that lead to female elite players in football quitting or continuing their careers, have not been further studied, neither in Norway or internationally. Few studies have examined the early drop out of the career of female elite football players. Based on statistics on participation in various sports federations in Norway, the Norwegian Football Federation is at the top for both men and women in terms of the number of active members. Football is the sport in Norway that most Norwegians participate regardless of gender, but at the same time a sport where you experience large and visible differences between the genders. In addition, the statistics show that the difference between the average age in elite football among men and women has a difference of 3.8 years. Women stay behind here as well, just as they stay behind in the development of elite football. Historically, women's football has not lasted as long as men's football. As mentioned earlier, it was not until 1976 that women's football was recognized as a formal sport in Norway. Men's football has a history that stretches much further back in time, and this is reflected in the dominance of men's football in Norway, as in the rest of the world. As several of the presented studies has described - the conditions for female elite players have not been good enough for woman to fully invest in a football career.

The research question of this study is: Which factors lead to elite women footballers in Norway ending their career at a young age, and which factors influence those who decide to continue playing?

# METHODS

## Design

The study has a qualitative design using interviews and a phenomenological-hermeneutic approach to shed light on the research question (Tjora, 2017), by exploring elite female players' opinions, attitudes and experiences regarding the factors that made them end or continue their football career. The research project has been approved by the Norwegian Centre for Research Data (NSD), and all participants gave their signed informed consent.

## Participants

The participants were recruited via a strategic selection based on their characteristics and qualifications corresponding to the research question (Thagaard, 2013). A criterion for participation was that the female players had played at least 20 games in the Norwegian top league. The website of the Norwegian Football federation (NFF, 2021), together with that of *altomfotball* (altomfotball, 2021), were used to identify them. Information about the research project and the question of participation was sent to the manager of clubs in the Norwegian top league. They sent the information further to the individual players. In all, nine players made contact, willing to participate in the study. The selection consisted of five players who had recently ended their elite football career at an age between 19 and 24 (Mean = 21, SD = 2.3), and foue players aged 26–31 who continued to play during the 2020/2021 season (Mean = 27.8, SD = 1). There are no standards for early drop out or long participation in elite football, but the cut offs seemed reasonable according to average age among female and male elite football players. These players represented different clubs in the Norwegian top league, and had played for one or more of the following clubs: Klepp, Røa, Stabæk, Kattem, Sandviken, Arna-Bjørnar, Grand Bodø, Fart, Medkila, Amazon Grimstad, Kolbotn, Vålerenga, Fløya, LSK and Trondheims-Ørn.

## Procedures

A semi-structured interview guide with open ended questions was created (Thagaard, 2013). This included questions such as; "which factor do you feel was of importance to your ending/continuing with elite football?". However, some questions were also created based on the results of previous research. These included questions such as; "what was the importance of education in your ending/continuing with elite football?" and "what was the importance of finances in your ending/continuing with elite football?". To test the interview guide, a pilot interview was conducted with a still active, 25-year-old elite player, playing for a Norwegian top league club. The interview was conducted face-to-face at the home of the informant and took 120 min. The pilot interview indicated that most of the questions seemed relevant. However, because of the long interview, similar-sounding questions were deleted together with leading questions and questions that seemed unlikely to yield answers to the research question. In addition, small changes were made to the order of the questions. The first four interviews were conducted face-to-face at the football clubs of the informants. Because of the Corona situation, three interviews were conducted using the Teams app, and two interviews using the telephone. The interviews lasted between 40 and 190 min, 60 min on average.

## Data Analysis

All nine interviews were transcribed out of dialect into standard Norwegian (*bokmål*) to ensure anonymity. A phenomenological-hermeneutic approach to the data was used (Thagaard, 2013). That is, it was desirable to understand phenomena and situations from the point of view of the elite players, through them describing the world around them as they had experienced it (Thagaard, 2013). According to Thagaard (2013), hermeneutics

emphasizes the interpretation of a statement, and then looks for a deeper meaning content than that immediately evident. This was done via a coding process followed by a process of categorization. In the first phase, coding of all the statements made in each interview using the analytic program NVivo 12. These codes then formed the basis for the next step, the categorization of the codes by thematic relatedness, the codes not relevant to the research question being excluded. Categorization helps to structure the meaning from long interview texts, and to make it easier to find common features (Kvale et al., 2009). On account of the two different groups of informants, the codes were divided under the main categories: "reasons for" and "reasons for continuing career past average age". The codes represented different factors influencing elite players to: end their football career; continue their football career; or to both continue and end their career. The first process resulted in a rough categorization into 28 factors divided between the two groups. In the second analytic process, the 28 factors were used as a starting point to find common features in the data material. The 28 factors were divided into six new main categories in which factors from both groups were included, with 14 factors influencing elite players either to end or to continue their football career (**Table 1**).

## RESULTS AND DISCUSSION

The analysis revealed six main factors, as presented in **Table 1**, influencing whether players end or continue with elite football. These will be presented in more detail and further discussed.

### Extent of Internal and External Motivation

The analysis shows that motivation is a factor mentioned by all informants, in respect of both career ending and career continuing. Lack of motivation for using time, energy and money on football clearly influences the decision to end the football career. Similar findings are presented in the study by Brandt-Hansen et al. (2014), where lack of motivation was one of the three most important reasons for drop out from the elite level among Danish women players. Whether this concerns internal or external motivation is difficult to ascertain from the interview data, but it seems reasonable to suppose that both play a part in both career ending and career continuance.

The analysis showed little evidence of internal motivational factors among the elite players who ended their football career at a young age. A majority of the elite players described the motivation to play football diminishing throughout their career as they experienced life as an elite player becoming heavier and tougher, and they felt more and more that it came at the cost of other things. In the quote below, Andrea describes lack of internal motivation as a factor that seems to set her apart from those who still play elite league football:

> *[…] football is, really, not my whole life, even though I love it and like to be part of a team, I have so many other things that make me happy as well. […] So, I think that, in a way, I've not completely had that inner drive, and that has made me not want to commit 110%. I've gone – like - to see friends and gone to a party because that's how I am. I've gone on a cabin-trip rather than stay at home and get myself ready for a game in a fortnight's time.*

Concurring with Andrea's view, Berit also describes the large part that lack of internal motivation played in her decision to end her football career. She felt that motivation for other things was greater than motivation for football. To the question about why she, Berit, had chosen to end her career, she answered:

> *It was the training really that did it. And having to keep free those regular times outside of working and studying. So, it was really freedom that I wanted to feel, I think – to be able to decide for myself what to do with my evenings and not have to say no to so much.*

In contrast to these quotes, elite footballers who continue to play displayed a high level of internal motivation through their eagerness to play, as Frida says:

> *I actually decided when I was about 12 that I would play for the national team and set myself a goal then to do so. I've always had that eagerness to be able to play football and somehow make that happen.*

In addition, elite players described the inherent joy of playing the game itself and the training, as Gina thought, when she described what the main reason is she still plays elite football:

> *If I will say one thing … […] Then joy. I like it so much. I'm a person who plays football and trains and finds joy in it.*

This finding is supported by the study of Brandt-Hansen et al. (2014) where joy in the game, the joy of performing for yourself and the possibility of improving oneself, appeared to be the most important motivational factors for female Danish footballers at elite level.

### Financial Circumstances and Total Load Level

The analysis showed that financial circumstances were a factor of significant importance, for both career ending and career continuing elite players. Danielle makes clear the issue of lack of wages:

> *You can't really go through the whole of your 20s and start of your 30s with what is far below the minimum wage in Norway. It demands a lot of motivation and hard work if you are to carry on without a salary you can live on, and at the same time retain the possibility to doing well in studies, and in football as well.*

Of the players who had ended their elite football career, most had combined football with work when they were active. In addition, three of the five former elite players had studied whilst they played football. Gjerset et al. (2015) defines total load as the sum of the load from trainings and competitions, as well as other mental and physical strains the athlete is disposed of in an everyday life. In this study, the informants focus on work and studies as other physical strains that have an impact on the total

**TABLE 1 |** Factors influencing elite players either to end or to continue their elite football career.

| Main categories | Sub-categories<br>Factors influencing ending of elite career | Sub-categories<br>Factors influencing continuation of elite career |
|---|---|---|
| Internal and external motivation | -Lack of internal and external motivation | -High internal and external motivation |
| Financial circumstances and total load level | -Financial worries<br>-Little financial support from the club<br>- Lack of facilitation to make the elite players everyday life easier and more professional<br>-High levels of stress according to personal finances | -Financial security from jobs outside football<br>-Professionalism of the club<br>-Growth of women's football<br>- Good facilitation by the club to make the elite players everyday life easier and more professional.<br>-Lower levels of stress according to personal finances |
| Serious injuries over time or not | -Injury over time | -No serious injury over time |
| Concerns about the future and the need for education | -Expectations for the future<br>-Strong desire to study<br>-Difficult to combine study and football | -Have completed the education<br>-Live as full-time professional |
| Trust from the coach and playing time | -Lack of trust from the coach and playing time<br>-Unhappy with the coach | -Lots of trust from the coach and playing time<br>-Feeling of mastery<br>-Joy of playing and developing oneself |
| Prioritizing football, or not | -Other interests than football<br>-Other priorities | -Few other interests than football<br>-Football as a priority |

load. Former player Cecilia describes the stress of devoting so much time and energy to work and earning a living.

> *The help that you might have received that would have made it possible to carry on a bit longer would of course, playing at the top level, have been some kind of financial compensation. Had you been able to cut one thing, that you had to work part time beside playing football and full-time study. [. . . ] Compensation has mostly to do with that, I think that some financial support could have helped many of us. I know that with the friends I have who earn a little bit, that they then can at least earn a little so they can have a somewhat smaller job outside football and just that helps. That they can work 80% instead of 100%. I think that would have helped.*

Unlike the elite players who have ended their football career, the players who continued their career have been offered better pay and conditions from the club, as Gina explains:

> *I understand why so many give up. When I look back, if I had gone up in pay to the level I have now, I would have had to have thought about it too. Because for a long time it didn't really work.*

Of the nine elite players who took part in the study, only two lived as full-time professionals. Four received, or had received, a wage from their club but this was not enough to live on without a second job or a study loan from the state. There is much that suggests that our informants were representative of women footballers in Norway. Several, however, made the point that considerable change has occurred during their career. They describe financial developments in recent years associated with the overall development of women's football in Norway. This is supported by Balsvik (2019), pointing to a process of positive change in Norwegian women's football during these years, not least increased sponsorship after 2017. Balsvik describes the positive effect of the commercialization of, and investment in, women's football in Norway during the past few years. On these grounds, there is reason to suggest that those elite players who had ended their football careers in 2016 or earlier, probably did not have the same financial starting point as the still active elite players:

> *[..] if there could have been just a bit more money or flexibility, I think it would have made things a bit easier, and easier to carry on. I felt very strongly that I simply must work to earn some money because you just didn't earn enough from football. [. . . ] Of course, you had bills needing to be paid, I was terribly aware of that (Jessy).*

The analysis suggests that these financial concerns and expectations were not an issue earlier in the player's career but grew with time. When asked what impact finances had had on her football career, Jessy answered:

> *Not much, but mostly because I gave up when I was 21. So, it didn't have the greatest effect on me. When you're still at school, living at home, get the cost of your kit covered and have four or five thousand a month, that's completely OK. In the USA as well pretty much everything was covered, but when you're studying or doing other things, four or five thousand is nothing. So, it would have affected me had I carried on. But no, when you're 17 or 18 and living at home it doesn't matter much.*

Jessy's view was supported in the interviews with the players who were continuing their career. These players currently have an average age of 27.8 and confirmed that with increased age come financial anxieties. This may, therefore, indicate that the need for money, and worries related to finances, often come at an age where you become more independent of your parents and in connection with moving away from home and establishing

yourself. This was also the understanding of Brandt-Hansen and Ottesen (2017). Of the 102 elite footballers taking part in their study, the majority were in the age range 26–32 and had a full professional contract. This shows a clear tendency for both the possibility of and need for a full-time contract to increase with age. That 41% of these elite players still lived at home with their parents shows that their need for financial support was not as great as that of elite players living on their own and having greater financial outlay (Brandt-Hansen and Ottesen, 2017). In her answer, Gina confirms that the need for better financial circumstances increases with age.

> *It works at a certain age, and it works for a time. As I say, when you're 19,20,21,22, then you can be grateful for the little you have. But then comes a time when you just need more. And if you don't get it, then all that you have got from football that has counted until then, doesn't add up anymore. Other things have their own weight. You want to manage on your own, get yourself a job and cope with daily life without being worried. Because those worries cost a lot of energy. So, I think many have experienced that.*

Even though all the elite footballers still playing received either full or partial support from their club, there were several who nonetheless encountered financial difficulties at certain points in their career. Gina expressed her thoughts about, and experience of, these tough times in the following way:

> *It's a question of whether it works at all. Having to pay for food, petrol, bills without being anxious. Because there were quite a lot of years when I was anxious. There was one time when I just went to pieces, because it was like, "I don't have the means, I don't have any money." I don't like it being like that, it's awful.*

Kaelberer (2019) concludes that the interaction of sports associations and clubs, business sponsors and the media, prevents women's football from effectively challenging hegemonic masculinity in German football. This partly because <10% of newspaper coverage or television broadcasting is devoted to women's sport, he argue, and states that to work against hegemonic masculinity requires greater societal and popular support.

However, our findings also show that the interests in female elite football increases, and the financial circumstances among female elite players are getting better. This is in accordance with Kaelberer (2019), who claims that female football players have made some forays into a previously exclusively masculine preserve. He highlight that more people pay attention to female football, and that the earnings for female football players have increased. Furthermore, female football players have started exploring new forms of femininity that include masculine traits such as self-confidence, athleticism and muscularity.

Despite many female elite players in Norway having similar experiences and maybe needing a job or qualification alongside football, it is reasonable to believe that financial developments within women's football in Norway in recent years have affected female elite players' financial circumstances. This development is confirmed by those players who have continued their career when they talk about the comparison between today and earlier, describing, now, a feeling of financial security, either as fully-fledged elite players or with an optimal combination of salary from club and job or study. They point to the introduction of "professional days" as representing a significant improvement. This is an arrangement in which the clubs receive support from *Toppfotball kvinner* (the League Association for Women's Football) to cover the wages of players having days off work to be able to train earlier in the day, and train more during the day. Frida describes this below:

> *No, it was when they began to introduce professional days amongst other things. It meant that we could begin to train earlier. And, of course, that we have the stadium, our own pitch, own changing room, somewhere to eat, could wash clothes. Little things like that. If it had been men's football, it would have meant little to them, but it makes such a difference for us. Just being able to wash clothes and get an evening meal once a week. Little things that left us pleased.*

Our informants' descriptions of changes in the economic conditions within women's football are in keeping with the findings of the study by Wang (2019). Our findings, however, contrast with those of Brandt-Hansen et al. (2014), who found that neither money or other material benefits had particular significance for the motivation and ambition of elite female Danish footballers. One reason why finances are proving to be more important for the motivation of the elite Norwegian female players in our study may be the increasing prominence of women's football in recent years. It is natural to suppose that the expectations of these players would rise in line with this development, and the possibility of earning money is significantly greater now than when Brandt-Hansen et al. (2014) undertook their data collection. On the other hand, the opportunity for elite female players to earn more money can lead to more expectations and commitment to football. A consequence of this can be less time to study, having an outside employment, or doing other things beside playing elite football. It could therefore become more difficult to get time to take an education and having this as a security after ending the football carrier. For two of the elite players who ended their football careers at a young age, they had other interests and other priorities alongside football. Expectations to prioritize football will naturally be bigger when the players are full-time professionals, than when they are semi-professionals. However, it is not given that all women football players want to be a full-time professional.

According to this finding, we will argue that this development is actually challenging the hegemonic nature of football, which is important according to Kaelberer (2019), and making football an arena for more than the performance of hegemonic masculinity. Although, for many elite women footballers, a job or training in tandem with football will be necessary for them to survive financially. An understanding of female elite players' total burden can be closely linked to the term "dual careers" used to illustrate the demands placed on elite British female players. Like the British players in the study by McGreary et al. (2021), our analysis shows that the Norwegian elite players in this study experienced similar challenges in having dual careers. For those players who had ended their career, financial worries and hence a high level

of stress had had an indirect effect on them quitting their football careers. This finding is consistent with Grygorowicz et al. (2019), who found that too little time for training due to the demands of work and study was the commonest reason for the Polish players who participated in the survey giving up their football careers.

Through the analysis, it emerged that the lack of pay in women's elite football created a challenging situation, entailing a lot of work and/or study, and thereby a high total load, including for the elite players who still played at top level. This also emerges from the interview with June, who now gets her income through a professional contract - something she did not have before:

> *If I compare it. It's only now that I realize how difficult it was. I went to college. Cycled there and was there until three at least and then cycled straight to training with team meetings and a quick hello. So, I got home, ate dinner and went to bed. So, it was very hectic and a high total load. I noticed that I didn't get either enough food or drink and very little rest and recuperation. While now it's almost like I don't quite know what to do with myself during the day, but I at least get time to recover and get enough sleep and feel that my body is more in balance as a result. That's really how it should have been for many more people.*

In summary, our findings indicate that a challenging financial situation and high levels of stress factors contributing to the elite players ending their football career. At the same time, these were also factors mentioned by the elite players who still play football when asked about possible reasons why they have considered ending their football career. In a study, Lie (2017) show that men on the national football team earns an average of 640,000 Euro more a year than a woman on the national football team. These differences are also clearly shown in our study, as the majority of the informants lived as semi-professional players and gave the impression that they are not or have not been well paid from the football club they played for.

## Serious Injuries Over Time or Not

The analysis showed that a long injury layoff was a factor mentioned in relation to several players who had dropped out. Cecilia, Danielle and Jessy, who had all ended their football career, had suffered severe injuries which would have required long rehabilitation in order to return to full fitness. Each had suffered a different injury, but the common denominator was an uncertainty related to the duration of the injury, whether they would be completely fit afterwards, and the fear that they could injure themselves again. All three had had future plans for their football careers, with Jessy still possibly a member of the national team and Danielle and Cecilia having just changed clubs. Asked whether they would have continued their career had they not been injured, all three answered that they would most likely have played on for some years. Despite all three describing several factors as contributing to their retiring, the injury seemed to be the triggering factor. Jessy experienced that her cruciate ligament snapped for the second time during her football career:

> *[. . . ] ..and, after that, I trained hard and was ready to play again, but I knew that my motivation had gone down with the second knee injury, and I had no wish to see it happen again. And there was something to do with finances on top of all that as well. As a woman footballer in Norway, it hasn't, in a way, been profitable. And although I'm not alone in that, I've had to work alongside the football the whole time.*

This agrees with earlier research into cruciate ligament injuries in footballers. According to Sandon et al. (2015), there is a greater risk of cruciate ligament injury for women than for men. There are also fewer women than men who have returned to football after such an injury. One reason for this may be that male players have a job offering good financial provision, while the majority of female players are semi-professionals without such good conditions (Gammelsæter and Solenes, 2013). This understanding is emphasized in the interviews with Jessy and Cecilia, who say that the injury, taken together with the financial strain, was the reason they chose to end their football career. The financial strain was not an issue for the third player who chose to end her career, as she was living at home at the time.

All the players still active in elite football said that they have suffered minor injuries during their career but described themselves as fortunate not to have suffered severe injury leading to a long layoff. Of the four still playing football, only Gina said that injury had affected her career. She has struggled with stress injuries and played many games while in a lot of pain. However, she has felt that the team depends on her, and has therefore been favored by the coach despite her injuries. Based on this, it can be argued that none of the elite players who still play football have experience of "time-loss injuries", as they have not been away from training and matches for long periods due to injury (Fuller et al., 2006).

## Concern About the Future and Need for Education

The results show a contrast between players who have ended their career and those who have continued theirs, in terms of anxiety about the future. On the one side, were three out of five elite players who described worries about the future as being a factor contributing to them ending their football career. On the other hand, none of the elite players who have continued their football career conveyed any sense that they thought of concern about the future as a factor that might make them give up.

A summatory finding of the analysis is that all five elite players ended their career whilst engaged in gaining qualifications. They all said that the combination of playing and studying was demanding, and that it influenced their decision to end their career. Several made the point that the motivation to study was greater than that to continue playing football, as Cecilia says:

> *[. . . ] In my case, I knew that studying was more important than the football, which meant that for me it was not enough to play football and try to rely on that, and work part time somewhere just to get an income. I had always known that I would study and knew what I would do, and that it was more important to me, plain and simple.*

What Cecilia said agrees with what players have said in several other studies. McCormack (2011), Gammelsæter and Solenes

(2013), and Brandt-Hansen and Ottesen (2017) all emphasize, in their studies, the importance education holds for elite female players. The reason for this is often held to be that the future prospects of female elite players, compared to male elite players, more often involve less accumulated funds and thus a more uncertain financial future. For two of the former elite players in this study, Berit and Danielle, it was precisely expectations of the future that led them to enter into a course of study. After she found it impossible to combine her studies with football—which was a contributory factor in her decision to end her elite playing career—Danielle explained as follows:

> *As a female footballer, you live in the knowledge that you are engaged in something that, for everyone, or nearly everyone, will not be possible to live on. This was, in a way, the background to my beginning to study. And being a student was a lifestyle not really compatible with being a top sportswoman. If the conditions for being a footballer had been better, then perhaps I would have carried on.*

Of the elite players who were still active, three out of four had completed higher education. They had, therefore, succeeded in combining their football career with acquiring qualifications. Presently, only one of them uses her qualification and combines having a job with football. The others live either completely from football or receive an income from a scholarship or loan in connection with their studies.

> *I don't earn much from football, and I can't really just play football. There are lots who give up for that reason, so therefore I've taken a qualification as well and I'm really happy to have that. [. . . ] So, I think there's loads that needs to happen. It has to be made to work so that income stops being a factor. Now, I'm not scared for the future, in a way, because I have my qualification. I think there are lots who stop playing because it's difficult to study whilst you are playing football, or because they can't manage to combine football with a job (Heidi).*

Like Heidi, June and Gina managed to combine football and studying. The grant that came with the course was for her a solution making it possible for her to continue playing football.

Of the four elite players still active, three said, however, that they had considered stopping on one or more occasions. On this topic, they spoke of anxiety about the future, particularly in relation to having sufficient funds to provide for themselves. Frida was the only one who neither had a qualification outside football nor was working toward one. For her, qualifications were not something she thought of as being necessary given the life she was living. One reason for that may be that she had a full professional contract and was therefore not dependent on a grant or loan as Gina was. This chimes with Gammelsæter and Solenes' (2013) argument that fully professional players see themselves more as being employed and are therefore more willing to delay qualification.

## Trust From the Coach and Playing Time

Analysis of the interview material indicates that trust from the coach and playing time are related to the motivation to play elite level football. Among the elite players who have ended their career, little playing time had had a negative effect on their motivation, whilst playing time and the trust form the coach that came with it had a positive effect on those players who felt that they were being relied on.

Andrea and Berit described playing time and the coach's trust in them as being central factors in their having lost the motivation to play, which in turn led to them giving up. Both of them were regularly in the squad for both home and away games but started the majority of games on the bench and generally got little playing time. For them to be match fit, they were therefore required to play in second team games, often the day after the first team game. They describe, therefore, a very high level of pressure involving a lot of traveling, which again affected their motivation. Andrea describes the feeling she had when she had little playing time and little belief in her from her coach in the following way:

> *[. . . ] So, I go there and bash myself on the head on Monday, Tuesday, Wednesday, Thursday and Friday to be good in training. And then you go there on Saturday and Sunday and think: "OK, now I'll be good when I get on the park." And then you don't get to play, and you become really disappointed and angry, because you have to start all over again the next week. So, you never get that affirmation. When you don't get it in training either, it doesn't help.*

In a study by Johansen (2016), female players stressed the need for the coach to see them, and for them to get the recognition they needed to perform in training and during the match. There was also shown to be a connection between the amount of playing time they got and the trust showed by the coach, and their attitude to the coach. These are signs of this in our study as well. The players who had ended their career because of little playing time expressed displeasure with their coach and had clear opinions about how things should have been done differently. Brandt-Hansen et al. (2014) found, in their study, that the factors: "football is fun", "the joy of performing" and "always possible to improve" were the most important motivational factors in Danish footballers playing elite level football. Loss of confidence as a result of little playing time leads to there being little pleasure, progress or performance for players, the result can be that they drop out. Andrea, a former player, elaborates on this:

> *How much you get to play depends on the coach's belief in you. If the coach trusts you and you do a good enough job, so you get to play. And if you are playing, then you most likely have a lot more fun. You don't become a footballer to sit on the bench. Everyone knows that. That's no fun at all, it's the match that's fun.*

What characterizes the elite players who have continued their football career beyond the average age, is that when they were first included in the first team at a Norwegian top league club, they gained the trust of the coach which in turn resulted in a lot of playing time. None of them had had to spend much time since then on the bench for their team, and all have been involved in age-specific national teams or the national first team throughout their footballing career. Based on this group of elite players still playing football having had so much playing time, the trust of their coach and, additionally, a background in

national teams, there are many indications that these players have maintained a high elite level and been among the very best. Even though women's football has come a long way in recent years, women footballers are still, by Gammelsæter and Solenes' (2013) definition, categorized as semi-professionals. Only a minority, therefore, live as full-time professionals and, naturally, it is elite players who are seen as being the best. That is, the eye of the needle is narrow and the probability of being among the best small, and thus the uncertainty regarding the future as a female elite player is great. The connection between a national team background and perceived trust and support from the coach is emphasized in the study by Brandt-Hansen et al. (2014). According to their survey, there was a significant difference in perceived support and trust among those who had a national team background, compared with those who had never been in the national team. In the present study, former elite player Andrea expressed a similar view, and implied, indirectly, that coaches often treated those in the national team and those who were not differently. When asked about what difference it would have made to her career had she been in the national team, she answered:

> *Well then would get the affirmation you need. And I think that all the trainers I've had – a strong word this – adore all those who've been in the national team. As if playing for your country differentiates those who are good from those who aren't.*

## To Prioritize Football or Not

The analysis shows that what characterized the elite players who had had little playing time in their football career, was that they had more interests which they prioritized over football, in comparison to the active elite players. There are some indications that Danielle and Andrea, who chose to end their elite football career, had interests outside of football that may have made it easier for them to choose to leave elite football. This becomes clear in the interview with Danielle when she was asked what factors influenced her to end her football career.

> *If I compare myself to others, so I have more outside interests. They don't have them [. . . ] I think that's because I have something to turn to after football, and it's been fine without football. I don't think it would have gone as well if I hadn't had it. I think I'd have struggled more.*

Andrea's answer to the same question was almost identical to Danielle's. In contrast to the elite players who had ended their football career, all the players who continued their football career said that football was their first priority, even at the expense of time with friends, parties, social events and other interests. This was clearly expressed by Frida:

> *Football has always been, has come first. It takes priority. It's clear that sometimes, really, I don't feel it so often, that I should have been at this party or [. . . ] It's clear that I don't get to see my best friend so very often, but no, it's not been that hard. Sometimes it's difficult living away from family and so on, but it's always been fine. It's been easy to prioritise.*

The above finding is in agreement with the results of Brandt-Hansen et al. (2014).

## Strengths and Weaknesses of the Study

The results are derived from in-depth interviews with five elite players who have ended their football career at a young age, as well as four elite players who have continued their career beyond average age. Taken together, the informants represented a wide range of elite players who have played and are playing in the Norwegian top league, and who have backgrounds and experience from various clubs around Norway. The findings are substantiated to a large extent by previous studies, but also add new knowledge. To be a qualitative study using in-depth interviews, the study includes an acceptable number of participants. Furthermore, that most participants seem to confirm the same main findings, strengthens the credibility and reliability of the study. However, due to the small number of respondents, it is necessary to be cautious about the generalizability of our conclusions. This might require quantitative studies, including statistical analyses. Nonetheless, the findings have a credible general validity on the basis that the participants seem to highlight the same factors as important according to drop out, or continuation, with elite football, and that all people involved in women's football have something to learn from these female players' experiences.

# CONCLUSIONS

The results of this study indicate that factors leading to elite players ending their football career at a young age are; low level of internal and external motivation, poor financial circumstances leading to high levels of stress, long absence through injury, concerns related to education, lack of playing time, and prioritizing other activities than football. Still active elite players reported higher level of internal and external motivation, better financial circumstances in football—and thereby lower levels of stress, no serious injuries and fewer concerns related to education, lots of trust from the coach and playing time, and also prioritizing football over other activities.

On the basis of the analysis, there emerged a clear distinction between the level of internal and external motivation between the elite players who have ended their football career and those who have continued theirs. External motivation in the form of benefits such as wages and recognition were absent from the career of those elite players who had stopped playing. For the elite players who were still active, expectations of better salary and perceived recognition were motivations to continue their football career. Low internal motivation to return from injury, or to play their way back into the team, were indirect reasons for elite players ending their football career. For the elite players who chose to continue their career, on the other hand, inner motivation in the form of the joy of playing football was emphasized as being absolutely crucial for them in continuing their football career. Another main finding was that long-term injuries and lack of playing time were underlying reasons for elite players ending their career at a young age, and that long injury breaks and lack of playing time seem to lead to the reduced priority of football.

On the other hand, freedom from injury and ample playing time appear to give football first priority, and thereby lead to a longer-lasting football career. A key finding in the study seems to be that female elite players today feel that their financial circumstances are improved, in comparison to a few years ago. For those who ended their career, the high level of total load appears to have played a decisive role in their decision. The elite players who were still active, earned better through football, had had fewer injuries, experienced being relied on in terms of playing time, gave football high priority and had a greater degree of internal and external motivation. In sum this constituted a lower total load enabling a greater investment in football, which in turn prolonged their career.

This study is giving new insights in women's football in Norway, that is a minor studied field in both Norway and internationally. Because of few researches on women and football, this study will be important to put the focus on women football and hopefully lead to more studies in this field of research. The study reproduces findings in other studies according to early drop out. New insight in this study shows is that establishing a family and having children not is necessary a reason for early dropout from elite football. None of my informants mentioned this as a factor that influenced the choice of dropping out of elite football at a young age. This study also shows the importance of getting enough playing time, even if it's because of a serious injuries or lack of trust from the coach. All five informants who left elite football at a young age emphasized that it was because of lack of playing time. This article indicates that the framework conditions for female elite players are about to change in step with the development of women's football both in Norway and internationally. Both better finances and less total load are described as better today than it was when the informants started their football careers. They describe an everyday life that is gradually becoming more and more professional and makes it easier to invest in a football career. This qualitative study contributes to a deeper understanding of factors that influence female elite players' football careers. Based on the fact that the study has few informants, the results as previously mentioned cannot be generalized to larger groups. Further research should therefore focus on a quantitative approach that will include a larger sample. In summary, I would argue that future research on women's football is necessary for girls and women to have access to relevant findings that can help improve their conditions in the future and hopefully help their football careers last longer. According to Barreira (2016) the age of the elite players was related to their performance. Getting female elite players to extend their football careers can therefore help to develop even better female football players in the future.

## 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 Norwegian Centre for Research Data (NSD). The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

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

## REFERENCES


altomfotball (2021). *Toppserien*. Available from: http://www.altomfotball.no/element.do?cmd=tournament&tournamentId=3&useFullUrl=false (accessed May 17, 2021).

Balsvik, M. M. (2019). *Kommersialisering og likestilling i norsk toppfotball: En kvalitativ studie av hvordan kommersialiseringsprosesser kan bidra til økt likestilling i norsk toppfotball* (Master thesis). Norwegian School of Sports Science, Oslo, Norway.

Barreira, J. (2016). Age of peak performance of elite women's soccer players. *Int. J. Sports Sci.* 6, 121–124. doi: 10.5923/j.sports.20160603.09

Brandt-Hansen, M., and Ottesen, L. S. (2017). Caught between passion for the game and the need for education: a study of elite-level female football players in Denmark. *Soccer Soc.* 20, 494–511. doi: 10.1080/14660970.2017.1331161

Brandt-Hansen, M., Therkelsen, G., and Ottesen, L. (2014). *Fra talent til Landsholdsspiller: Talentudvikling af Kvindelige Fodboldspillere*. Available from: https://nexs.ku.dk/forskning/idraet-individ-samfund/udgivelser/rapporter/2014/dbu-talent/dbu-talent.pdf (accessed May 08, 2021).

Connell, R. W., and Messerschmidt, J. W. (2005). Hegemonic masculinity: rethinking the concept. *Gender Soc.* 19, 829–859. doi: 10.1177/0891243205278639

Drummond, M. J. N. (2003). The meaning of boys' bodies in physical education. *J. Mens Stud.* 11, 131–143. doi: 10.3149/jms.1102.131

Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., et al. (2006). Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Scand. J. Med. Sci. Sports* 16, 83–92. doi: 10.1111/j.1600-0838.2006.00528.x

Gagné, M., and Deci, E. (2005). Self-determination theory and work motivation. *J. Organ. Behav.* 26, 331–362.

Gammelsæter, H., and Solenes, O. (2013). Money in–brains out? Institutional logics affecting athletes' preparation for alternative careers. *Eur. J. Sport Soc.* 10, 267–289. doi: 10.1080/16138171.2013.11687922

Gjerset, A., Nilsson, J., and Raastad, T. (2015). "Treningslære," in *Idrettens Treningslære,* eds I. A. Gjerset, J. Nilsson, J. W. Helge, E. Enoksen (Oslo: Gyldendal Undervisning).

Goksøyr, M., and Olstad, F. (2002). *Fotball!: Norges fotballforbund 100 år [Football: 100 Years of the Norwegian Fottball Association]*. Oslo: Norges Fotballforbund.

Grygorowicz, M., Michałowska, M., Jurga, P., Piontek, T., Jakubowska, H., and Kotwicki, T. (2019). Thirty percent of female footballers terminate their careers due to injury: a retrospective study among polish former players. *J. Sport Rehabil.* 28, 109–114. doi: 10.1123/jsr.2017-0190

Johansen, E. (2016). *Utviklingsarena til toppfotballen. En studie av ungdomsspillere som rekrutteres til Toppserien eller Eliteserien* (Master thesis). Tromsø: The Arctic University of Norway.

Kaelberer, M. (2019). Gender trouble on the German soccer field: can the growth of women's soccer challenge hegemonic masculinity? *J. Gender Stud.* 28, 342–352. doi: 10.1080/09589236.2018.1469973

Kvale, S., Brinkmann, S., Anderssen, T. M., and Rygge, J. (2009). *Det kvalitative forskningsintervju. 2th Edn*. Oslo: Gyldendal akademisk.

Lie, S. L. (2017). *Enorme kjønnsforskjeller i idretten*. NRK. Available from: https://www.nrk.no/sport/enorme-kjonnsforskjeller-i-toppidretten_-norske-menn-tjente-100-millioner-mer-enn-norske-kvinner-1.13806390 (accessed February 15, 2022).

McCormack, C. (2011). *Education and Elite Soccer: An Examination of the Female Experience in Norway and Canada: A Qualitative Study of Elite Female Soccer Players in Norway and Canada. I.* Oslo: Oslo University.

McGreary, M., Morris, R., and Eubank, M., (2021). Retrospective and concurrent perspectives of the transition into senior professional female football within the United Kingdom. *Psychol Sport Exerc* 53, 1018–1055.

NFF (2021). *Norges Fotballforbund*. Available from: https://www.fotball.no/

Paechter, C. (2019). Where are the feminine boys? Interrogating the positions of feminised masculinities in research on gender and childhood. *J. Gender Stud.* 28, 905–917. doi: 10.1080/09589236.2019.1597339

Sandon, A., Werner, S., and Forssblad, M. (2015). Factors associated with returning to football after anterior cruciate ligament reconstruction. *Knee Surg. Sports Traumatol. Arthrosc.* 23, 2514–2521. doi: 10.1007/s00167-014-3023-4

Thagaard, T. (2013). *Systematikk og innlevelse: en innføring i kvalitativ metode. 4th Edn*. Bergen: Fagbokforlaget.

Tjora, A. H. (2017). *Kvalitative forskningsmetoder i praksis (3. utg. utg.)*. Oslo: Gyldendal akademisk.

Tucker, L. A., and Govender, K. (2017). 'Sticks and Stones': Masculinities and Conflict Spaces. *Gender and Education* 29, 352–368. doi: 10.1080/09540253.2016.1156059

Wang, M. (2019). *Organisasjonsidentitet i fotball: en kvalitativ undersøkelse av Vålerenga Fotball Damer sin organisasjonsidentitet*. Oslo: Norwegian University of Life Sciences, Ås.

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# "From everything to nothing in a split second": Elite youth players' experiences of release from professional football academies

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Previous research has assessed the affects release from football academies has on psychological distress and athletic identity of players. However, there has been no qualitative research exploring players' experiences of the release process. This study retrospectively explored players' lived experiences of being released from a professional football academy, having completed a scholarship (from ages 16–18). Four male football players (age 21.6 ± 1.5 years) who had experienced release from professional academies participated in in-depth semi-structured interviews. Data were analyzed using Interpretative Phenomenological Analysis. Four super-ordinate themes were interpreted from the data: Foreshadowing release—"left out in the cold", The process of release, Support during the process of release and New beginnings—"there's a bigger world than just playing football every day". Players reported that their contract meeting was a traumatic experience, and they experienced psychological difficulties in the longer-term following release. Factors that compounded the players' release were: a lack of aftercare being provided by the players' professional clubs for their wellbeing, and a disuse of social support, which hindered their transition out of full-time football. Context relevant recommendations are made to help improve the release process for elite youth football players.

KEYWORDS

**athletic identity, deselection, elite sport, football, interpretative phenomenological analysis, non-normative transition, soccer**

## Introduction

Of the 1.5 million boys who play organized youth football (soccer) in England, only ∼180 will be signed professionally by a Premier League club, a success rate of 0.012% (Calvin, 2017). In 2011, 13,612 boys made up the professional football academy system in England. Despite this, 50% of all academy players leave the system before they are 16 (Premier League, 2012). Furthermore, ∼98% of players awarded with an academy scholarship by English clubs at 16 are no longer playing in the top five tiers of English football at 18 (Calvin, 2017). These statistics indicate that a large number of boys do not realize their dreams of becoming professional senior footballers and are

released from academies each year. Yet, with the focus of talent development football research on those who "make it", this issue has received limited attention (Gledhill et al., 2017). Career transitions are normative or non-normative turning phases during an athlete's career (Stambulova et al., 2009). A normative transition is one an athlete typically expects to make, usually when exiting one life stage and entering another, such as the transition from youth to senior level sport (Wylleman and Lavallee, 2004). Release from a professional football academy is the termination of a player's contract and playing status with that club, and is an example of a non-normative career transition, whereby the athlete does not expect or anticipate the transition (Webb et al., 1998). Non-normative athletic career termination, such as release, can result in problematic transitions (Brownrigg et al., 2012). Factors contributing to problematic transitions include: when termination is involuntary, the development of a high athletic identity, when the athlete has limited control regarding the continuation of their athletic career and when the athlete perceives that they have failed to achieve their sporting goals and unfulfilled their sporting potential (Warriner and Lavallee, 2008; Park et al., 2013). When athletes' careers are terminated involuntarily, they are more likely to experience emotional disturbance and psychological distress, such as depression, anxiety, identity crisis or confusion, loss of self-worth or esteem, suicidal ideation, attempted suicide and trauma (Erpič et al., 2004; Warriner and Lavallee, 2008; Wippert and Wippert, 2008, 2010). Such negative psychosocial outcomes are dramatically reduced when athletes have autonomy over career termination (Park et al., 2013). Further, some research has highlighted that there may also be positive outcomes associated with transitioning out of elite sport (Knights et al., 2016). For example, Williams and MacNamara (2020) conducted retrospective interviews with ten former professional academy cricket and rugby players concerning their release, with players revealing during their time in the academy, they felt they had developed a series of key psychological characteristics that had supported their future success in other domains. Positive growth following players being "cut" from a provincial soccer team has also been reported previously, despite participants describing it as a traumatic event (Neely et al., 2018). However, the professional football academy system in the UK represents unique and complex psychosocial challenges for young aspiring athletes (Champ et al., 2020; Mitchell et al., 2020) and such positive outcomes have not been shown.

In 2012, the English Premier League and Football Leagues were at the forefront of implementing a new long-term strategy known as the Elite Player Performance Plan (EPPP) (Premier League, 2012). The plan was designed to increase the number of home-grown players participating within these leagues (Roe and Parker, 2016). Academies were audited as part of the process and were classified into four categories; with category 1 being the highest level (Premier League, 2012). Category 1 academies receive the most funding, are able to provide a wider range of support and are licensed to recruit and develop players from 5 to 21 years of age. Further, they are obliged to provide up to 8,500 h of coaching for players who enter the system at 9 and leave at 21 years old. A typical category one academy in England has a reported annual spend between £2.3 and 4.9 million (Larkin and Reeves, 2018). In contrast, the lower category academies receive less funding and provide fewer coaching hours (Webb et al., 2020). Despite strong commitment, dedication and personal sacrifices (Holt and Mitchell, 2006), players enrolled on a youth scholarship at a professional football club have not yet secured a professional contract, and therefore have very little control over their career development both short-term and long-term (Roderick, 2006). Not gaining a professional contract has previously been reported as a perceived failure by academy players, leaving them uncertain and fearful of this possibility (Sagar et al., 2010). Professional football culture and the academy culture environment has been described as ruthless and cutthroat in nature, with a high player turnover (Nesti and Littlewood, 2011). This can culminate with a player's release from a professional football academy, which has been associated with high levels of psychological distress, identity crises, and ineffective coping (Brown and Potrac, 2009; Blakelock et al., 2016, 2019).

Blakelock et al. (2016) assessed the likelihood of 91 elite youth footballers, aged 15–18 years, experiencing clinical levels of psychological distress following release. Psychological distress was assessed using the General Health Questionnaire-12 (Goldberg and Williams, 1988) which was completed at three time points: 7–14 days before, 7 days after, and 21 days after retain/release procedures. Released players experienced significantly higher levels of psychological distress than retained players, both 7 and 21 days after retain/release procedures. Furthermore, the levels of psychological distress reported by released players were reflective of severe psychological distress (Rai et al., 2012), at levels generally requiring service input from mental health professionals (NICE, 2011). In a follow-up study, Blakelock et al. (2019) also showed that the use of avoidance coping strategies following release was positively correlated with higher levels of psychological distress in elite youth footballers. These studies suggest that following release, players may be more likely to engage in maladaptive strategies to cope with their release and experience high levels of psychological distress. However, these studies only considered effects across a 6-week period at the time of release, and not the longer-term effects release could have on players. There is a need to explore how each individual actually makes sense of this experience, and how they cope with any longer-term psychosocial effects (Brown et al., 2018). Thus, the large number of boys being released from academy football (Premier League, 2012), coupled with clinical levels of psychological distress associated with release (Blakelock et al., 2016, 2019), indicates a necessity for a more detailed exploration of players' experiences and individual stories of the release process (Brown et al., 2018).

A major factor associated with problematic non-normative transitions, such as release, is the loss of a high athletic identity, resulting in an identity crisis (Lally, 2007; Warriner and Lavallee, 2008). Elite youth footballers are usually recruited into professional academies between the ages of 5 and 10 years (Green, 2009; Mitchell et al., 2020). This has raised concerns over the increased professionalization of football at a younger age and the potential detrimental impact this may have on players (Relvas et al., 2010). Fundamental to this increased professionalization has been early entry into academy environments, which places significant demands on young players and is viewed as their first entry into the football "profession". Players can be formally associated with a club's academy from 9 years old and train between 2 and 4 times per week, as well as undertake competition on a weekend (Richardson et al., 2004). The prioritization of football, and the demands placed on players (i.e., attending training and fixtures regularly, and making sacrifices to the social and educational aspects of their lives, such as the day release program) can result in the creation of a strong athletic identity (Brown and Potrac, 2009; Mitchell et al., 2014). Research has suggested that the formation of a strong athletic identity in elite youth footballers can cause emotional disturbance when this identity is disrupted by release and hinders players adjusting to life away from full time football (Brown and Potrac, 2009). As so few boys sign professional contracts at 18 years (Green, 2009; Calvin, 2017), many may encounter identity crises and psychosocial problems when transitioning away from being a full-time footballer. The onset of such distress can be related to the concept of symbolic loss; through involuntary career termination, players lose the primary source of their identities and what has been the focus for most of their lives, causing an identity crisis (Brown and Potrac, 2009). However, identity disruption may form just one aspect of a player's experience during and after release. A more comprehensive exploration of individual's stories is necessary to discover personal experiences of release (Brown et al., 2018).

As far as the authors are aware, there have only been three studies exploring youth player release from professional football academies: from a clinical psychological perspective (Blakelock et al., 2016, 2019), and an athletic identity perspective (Brown and Potrac, 2009). A recent review of talent development in football highlighted players who were unsuccessful in their attempts to become professional footballers are under-represented in the literature (Gledhill et al., 2017). Therefore, it is vital that the understanding of players' perspectives and experiences of release, which remain largely unexplored, are enhanced further (Wilkinson, 2021). Previous research suggests that released elite youth footballers may encounter psychosocial problems (Brown and Potrac, 2009; Blakelock et al., 2016, 2019), but it is unclear how they cope with the long-term effects of their release, or how they view their experiences of being released. Thus, there is a need to explore the release process in greater depth, and through an idiographic approach, the individual stories of elite youth players who have been released. Therefore, the aim of the current study was to retrospectively explore players' experiences of being released from a professional football academy.

# Method

## Philosophical underpinnings and qualitative design

In terms of a philosophical orientation to this study, our underpinning epistemological approach was constructivist, from a theoretical standpoint of interpretivism. Constructivism asserts that people construct their own understanding and knowledge of the world through experiences and reflecting on those experiences (Honebein, 1996). Thus, we adopted a qualitative, interpretative phenomenological analysis (IPA) approach (Smith and Osborn, 2004). IPA has origins in phenomenology, hermeneutics, and idiography, and aims to understand individuals from a particular population's "lived experiences" through participants sharing stories, thoughts and feelings about their experiences of specific phenomena (Smith and Osborn, 2004; Langdridge, 2007). IPA involves a two-part interpretation, termed a "double hermeneutic", whereby the participant is trying to make sense of their world and the researcher is trying to make sense of the participants making sense of their world (Smith and Osborn, 2004). As a focus of the present study was to explore each participant's individual story, IPA was deemed the most suitable approach due to its idiographic nature, which focuses on the particular and unique details of each case (Smith and Osborn, 2004). An idiographic approach is more explicit in IPA than in other approaches to qualitative research (Brocki and Wearden, 2006). Given that each individual's experience of release was likely to be different, it was hoped that IPA's focus on idiography would allow us to highlight both the divergent and convergent aspects of the participants' experiences of release. The aim of the present research then was not to describe objective reality, but rather to explore and understand each participant's view of the world as related to the phenomenon of interest (Smith and Osborn, 2004).

## Participants

IPA studies use homogenous purposive samples, to ensure the experiences of the most appropriate persons for the research question being addressed are sought (Smith and Osborn, 2004). Thus, following institutional ethical approval, four male footballers (age 21.6 $\pm$ 1.5 years, $M \pm SD$) that had experienced release from elite level youth football in England were invited to participate. To meet the sample criteria for the study,

participants had to have: (a) completed a 2-year scholarship (from ages 16–18 years) at a professional football academy, within categories 1–3 of the Elite Player Performance Plan [EPPP (Premier League, 2012)], and (b) been released from a professional football academy within the last 5 years to reduce any significant memory decay or bias (Pillemer, 2001). The interviews were conducted within a maximum of 3 years after the players' release. All participants provided informed written consent prior to participation in the study.

## Player biographies

We have provided a brief contextual synopsis for each participant, in alignment with IPA, for the reader to feel as close as possible to each player's story. The descriptions reflect our interpretations of the players' stories and footballing journeys. To protect their anonymity, we gave each player a pseudonym and their respective clubs and national teams were not named. Keith played for a category 3 academy whilst the other three players played for the same category 1 academy.

**Keith** is 23. He signed for a professional academy at age 13 before completing his 2-year scholarship. He earned a 1-year professional contract during which the club won a lower division title. He was then released at age 19. Keith moved into semi-professional football and was placed on the national "C" team contingency list—international recognition for semi-professional players under 23. Keith continues to play semi-professional football whilst working as a bricklayer, having recently completed a night-college course. He has a child.

**John is 22**. He signed for a professional academy at age 8 before coming out of the academy a year later by choice. Having re-signed for the same club a year later, he completed a 2-year scholarship, gaining international recognition with his national team's under 19's in his second year. John was then offered an extended scholarship for a further year due to injury before being released at age 19. After unsuccessful trials at several professional clubs, John signed for a full-time semi-professional club. Following numerous knee injuries that required four operations John had to quit playing football. John is now an estate agency valuator actively pursuing a career in the fire service.

**Arthur is 22**. Arthur and John played for the same professional club in the same age group. Having signed for a professional academy at age 8, he completed a 2-year scholarship and a 2-year professional contract at the club. During his time at the club, he earnt international recognition with his nation at U16, U17 and U18 level. Following two hip operations Arthur was released by the club at age 20. Having had one unsuccessful trial at a professional club he signed for a part-time semi-professional team. However, due to a hip injury, he quit playing football. He is now an ambulance technician.

**Ben is 21**. He signed for a professional academy at age 9 before completing a 2-year scholarship and a 1-year professional contract. Ben was then released at age 19, before unsuccessfully trialing at numerous clubs, both in the UK and the USA. He then signed for a full-time semi-professional side before moving into part-time football when his previous club had financial issues. During his semi-professional career he has gained senior international recognition for his national team. He currently works in a warehouse but maintains a strong desire to re-enter full-time football.

## Procedure

Single retrospective, in-depth semi-structured interviews were conducted individually with each participant. Interviews lasted between 52–81 min ($M \pm SD = 71 \pm 13$ min). Interviews took place in locations mutually agreed with the participants, where they felt relaxed and comfortable to share their experiences of release with the interviewer. As recommended by Smith and Osborn (2004), a semi-structured interview guide was designed, to facilitate a flexible interview format. Adopting a semi-structured interview format created a dialogue between interviewer and interviewee, allowing both the participant and interviewer to discuss topics that arose (Smith and Osborn, 2004). This aligned with IPA as it allowed the interviewee to speak about their feelings and experiences in great depth, resulting in richer data being generated. The participants were initially asked general questions about themselves to build rapport and ease them into the interview process. The main topics of the interview involved asking participants to describe their experiences of the period leading up to, the period around the point of and the period following release, to get to the heart of the players' lived experiences of the release process; for example, "Can you tell me about the period leading up to your release?" and "Can you tell me about the day you were released?". Each interview was audio-taped *via* a Dictaphone before being transcribed verbatim, yielding 107 pages of single-spaced text.

## Data analysis and interpretation

Guided by the principles of IPA (Smith and Osborn, 2004), data analysis began with re-reading the interviews several times, to become as familiar as possible with the data. Then, initial annotations were made, identifying anything of interest or significance, before being transformed into concise phrases to capture the essence of themes. Here, attention was focused on the language used by the participant, including identifying repetition of particular words and the way that the account was expressed (Nizza et al., 2021). Also, we tried to move beyond what was explicitly said to gain a deeper understanding of the meaning that was attached to what was being discussed. Following this, connections between themes were searched for and identified, so they could be grouped together into superordinate themes. Lastly, the superordinate themes were

checked with the transcripts to ensure they reflected the actual words of the participants. The whole process, from initial notes to developing superordinate themes, was conducted for each participant separately. Finally, a cross-case analysis was conducted, in which themes and superordinate themes for each participant were assessed for similarities and differences. Identifying higher order concepts made it possible to link the participants' experiences, yet still reflect divergence and maintain the idiographic focus that is central to IPA (Nizza et al., 2021). As IPA arose from a phenomenological tradition that seeks well-grounded descriptions in the analyzed text, we strived to achieve this by showing rich descriptions from the interviews through quotes (Smith and Osborn, 2004).

## Methodological rigor

We aimed to follow the four quality indicators of a good IPA paper (Nizza et al., 2021). This included constructing a compelling, unfolding narrative, highlighting the existential accounts provided by the players, a close analytic reading of the players' words and attending to convergence and divergence in the players' stories (Nizza et al., 2021). We endeavored to ensure that we considered both the phenomenological descriptive part and the interpretative freedom of IPA (Smith and Osborn, 2004). To achieve these aims, the first author analyzed all material independently; with the second and third authors having the role of "critical friends" (Marshall and Rossman, 2015). The role of the "critical friend" is not to try and achieve consensus, or agreement, as this does not guarantee rigor or mean the "truth" has been found, but rather to encourage reflexivity by challenging one's construction of knowledge (Patton, 2015). Thus, the different perspectives offered by critical friends serve to challenge and develop the interpretations made by the researcher as they construct a coherent and theoretically sound argument to support the case they are making in relation to the generated study data (Smith and McGannon, 2018). Furthermore, the first author kept a record of interpretations of the data throughout the interviewing and analysis process, to allow reflections over time and reflexivity on our own interpretations (Tracy, 2010). Throughout the research process we tried to remain aware of our biases. The first author was a youth player in a professional football club academy from age 5–14, before being released. Therefore, it is unrealistic to think there may not be some biases toward the academy experience and release. However, the constructivist paradigm emphasizes that research is a product of the values of researchers and cannot be independent of them (Honebein, 1996). Further, IPA draws heavily on the philosophical work of Heidegger's (1962) hermeneutic phenomenology, which suggests we cannot ignore our biases, but rather interpret experiences based on our cultural and historical background - our prior understandings. These considerations allowed us to be reflexive throughout the research process (Tracy, 2010).

# Results

Themes have been organized into a coherent, unfolding narrative that is representative of the participants' lived experiences of their release. The results detail the players' release as a process; beginning with the lead up to their contract meeting, the point of their release and the period of time after their release. Four superordinate themes were identified and developed to reflect the process of release: foreshadowing release—"left out in the cold," "the process of release," "support during the process of release," and new beginnings—"there's a bigger world than just playing football every day" The resulting list of superordinate and subordinate themes is presented in Table 1. We have strived to highlight convergence and divergence between players' stories, with quotations—selected for their richness—used to illustrate these themes (Nizza et al., 2021).

# Foreshadowing release—"left out in the cold"

Through our interpretations, we felt the unique environment of professional academy football influenced the players' experiences of the release process. Contributing factors that underpin this unique environment were the uncertainty players felt in relation to their place within the academy and being marginalized by their clubs in the build up to their release.

TABLE 1 Table of themes identified from the interviews.

| Superordinate themes | Subordinate themes |
|---|---|
| Foreshadowing Release—"Left Out in the Cold" | • The nature of professional academy football<br>• Marginalized by the club |
| The Process of Release | • The contract meeting—"a traumatic experience"<br>• Psychological difficulties in the aftermath<br>• Accepting release |
| Support During the Process of Release | • Club aftercare<br>• Support from significant others<br>• Seeking professional support |
| New Beginnings—"There's a Bigger World than Just Playing Football Every Day" | • Moving on<br>• Growth after release |

## The nature of professional academy football

All the players expressed how unpredictable their footballing careers were, and the ups and downs they experienced. Keith summed up the unpredictable nature of football, and the "emotional rollercoaster" players experience day-to-day:

> "… with full time football you don't know.. every day is different, your emotions every day are different, you're physically different, you can have a great training session, you can have a shit one.. you don't know what tomorrow is gonna bring. Whereas at work you know you're gonna go work and you know what you're gonna do."

Players talked repeatedly about the element of luck involved, both in terms of injury, and getting the break they needed, to go onto a career in professional football. This unpredictability contributed to the players' experiences of release, as they were uncertain of their futures within football. Adding to this, all the players highlighted a lack of control and feelings of helplessness whilst pursuing their dreams of becoming professional footballers in their respective academies. This included the players' perceived inability to change the opinions of coaches and directors of football. Keith spoke candidly about his pursuit of becoming an established professional footballer:

> "I regret like not working harder but the carrot didn't dangle, if that makes sense? Like, they didn't give me that incentive. As if like.. 'cos I worked hard, but there wasn't that incentive, do you know what I mean? Whereas if they'd give me an incentive like, 'oh if you carry on the way you're going you'll be playing first team or you'll get your chance'. It was just kind of like, just not bothered, like if I go home or stay, no matter what I was doing, like in my head, no matter what I was doing I weren't getting noticed so.. you end up kind of sacking it off in the end."

Keith spoke about how that subsequently made him feel:

> "Shit. Like that's what I mean, you end up hating it don't you, there's no drive, there's no like, love for it, you just turn up, you do it, get through it and then just go home.. because you know even if you have a worldie training session, nothing's gonna matter."

Throughout his interview, Keith openly reflected on not feeling good enough to establish himself at senior first team level, but also discussed his interpretation of his situation—whatever he did was not going to get him noticed—a point echoed by Arthur. Keith and Arthur's insights reveal why players may not act in a volitional manner or positively self-regulate if the perceived reward for these behaviors is not there.

## Marginalized by the club

All the players talked of being marginalized by their club and coaches before the point of release. Arthur recalled one such instance at training in the lead up to his contract meeting:

> "I don't think personally they treat you as one of their players anymore, they treat you as just.. 'oh he's turned up to training again'.. so.. there was a few sessions where they'd do a small sided tournament.. and I'd just be a floater.. or I remember once, I turned up to training and they didn't even know that I was coming, and they didn't even put me in any of the teams.. erm.. and that was training with the first team as well, so I was looking forward to it, and then I walked up to the pitch and they said, 'oh Arthur, you're not in any of the teams'."

This public embarrassment and humiliation Arthur recalled in front of his teammates and first team players left him feeling angry, hurt, and ashamed. The marginalization by their clubs reported by the players is one way in which their release was compounded, adding to the negative emotions the players experienced during their time at the club and following their release. It is interesting to note whether this marginalization was particularly evident to the players at the time, or in trying to make sense of their experiences of release during the interviews, they were looking back for clues of what was to come. However, all participants noted instances of either themselves or teammates being marginalized and "left out in the cold", which suggests it is engrained within the game of football. This was typified by Arthur highlighting conversations the club had with his agent without his knowledge about the probability of his release, whilst Ben spoke of being left out of matchday squads in favor of trialists.

## The process of release

Through the players' stories and experiences of release, we interpreted their release as a process, rather than a singular event. While all players talked of an immediate, emotional response to being released after their contract meeting, for John, Arthur and Ben, their most severe psychological difficulties were experienced some time after the event of release.

### The contract meeting—"a traumatic experience"

All the players revealed being released was a traumatic experience and highlighted feelings of sadness, pain, and anger. The players were all released in the same way: their team gathered in a changing room and one-by-one, they were called

into their contract meeting—one of the common aspects of all the players' experiences of release. When the players discussed their release, the pain and emotion was evident as they recalled the events, which was typified through John and Keith's repeated use of the word "horrible" to describe their feelings around the time of their release. Players recalled feelings of anxiety, doubt, and uncertainty the wait for their contract meeting caused. John recalled the emotional trauma of his contract meeting and the subsequent aftermath:

> "..they said that I'm getting released.. 'but (professional club) really want you, they're gonna literally.. like they've got a two year contract, and you've just got to play well'.. then I'd hardly even spoke to my Mum and Dad, literally had to pack my bags and pretty much go the next day.. I thought I was fine, I didn't think I was bothered about it at all.. then I got to (professional club) and it literally all like, hit me, and I was thinking like.. I was literally gutted. I just remember like literally.. I think I just sat and cried in the room in (city of trial club). It was horrible."

Keith recalled how he felt immediately after being released in his contract meeting:

> "Yeah, it was.. emotional. Erm.. obviously you hold it all in but you're sitting there and it's like.. I've been there for five years, you know like the kit man, all the lads, the coaches and you literally get told no, and it's within ten minutes, you've got all your stuff and you're out and you never see them again.. so it's just kind of like from everything to nothing in a split second."

Through interpreting the players' reflections, this appears to be a defining aspect of the release process, and why it may cause such distress to players. In one moment, they are full-time footballers, which their identity is inextricably linked to; the next, this identity has been suddenly taken away, causing emotional harm and leaving the players questioning their place in their lifeworld. This shattering of identity was poignantly captured by Keith—"from everything to nothing in a split second"—and highlights the existential accounts the players gave of their release experiences.

## Psychological difficulties in the aftermath

John, Arthur, and Ben reported experiencing psychological difficulties in the aftermath following their release. John reflected on the psychological effects of his release:

> "To be fair, I've let it go now, and I think.. I think at the time I weren't that bothered. Obviously, I broke down at (professional club he trialed at the day after release) once, but that was like literally not even touching it.. my knee just kept swelling up, kept swelling, kept swelling up, I knew.. I knew I needed an operation like straight away, but I knew I had to find a club first. Then I was just playing on the swelling for about six months.. then it broke down and.. I had a massive operation, I knew about my knee, I knew I couldn't really.. I could have gone back to football but I knew mentally I couldn't.. then after that, I literally just remember.. I was like, so down. I had counseling and I just remember I had like, four.. four-hour counseling sessions and I must have just cried for about 45 minutes of each. Yeah, I felt well better after… I think it makes you a better person now 'cos you're so like resilient to most things."

John's words encapsulate his experience of release as a process, rather than just a one-off event. The quote begins by him playing down his psychological difficulties before he completely opens up by initially talking about breaking down at his trial club the day after he was released in his contract meeting. However, this emotional trauma "was like literally not even touching it," in terms of how bad it would get. Over 6 months after his release, and in combination with a career threatening injury, John spoke candidly of his severe psychological difficulties and seeking professional support. Finally, he discusses the increased resilience he now possesses following his experience of release. Evidenced by the pain and emotion they displayed during their interviews, both John and Arthur expressed the most emotional and psychological turmoil of all the participants following their release. This may be due to their release being coupled with career-threatening injuries. This finding is salient, as players who are released either due to, or with an ongoing injury, may be more susceptible to experiencing higher levels of psychological distress than players without ongoing or career-threatening injuries. Furthermore, Arthur and John's injuries were not recognized immediately as career ending, and they both went through arduous periods of pain and rehabilitation believing they would be able to continue playing.

Ben recalled the effects release had on him:

> "I won't lie to you, yeah I did get down after I left. Like, properly.. like I'm not gonna sit here and try and tell anyone it doesn't affect you, it affected me more, like.. a year after.. or like, 6/7 months after. When I hadn't been playing, the frustration set in and I was telling my parents, 'I don't care about football anymore'. I was literally.. I was so done with football."

Also, Ben expressed the psychological difficulty he experienced was partly due to financial worry:

> "Depression.. this is like purely financially as well, yeah. So.. basically, I'd been released for a little while.. I earnt a decent amount of money for my age.. when that stops happening, yeah, that's when you feel it. I promise you now. Honestly, not having the freedom that.. of having money.. like, literally man, that ruined me.. you're literally just

> watching your pocket.. plus my car, this that, like, you start adding everything up and it just.. like, it grows.. the burden of it all grows and.. that's when I started to feel down."

John, Arthur, and Ben appeared to experience severe levels of psychological distress following their release, encompassing feelings of depression, identity crisis and confusion, loss of self-worth and esteem, sadness, pain, and anguish. Furthermore, these three players endured delayed psychological difficulties between 6 months and 1 year post their release for a prolonged period of time. After the point of release, these difficulties seemingly worsened with time as the realization of their release sank in. In contrast, Keith did not report experiencing distress to the severe levels of the others in the longer term, instead highlighting the positive aspects of being released; "I think it probably had more of a positive effect in the end because I ended up enjoying it (football) again." Keith's quote highlighting his positive response and lack of psychological difficulties in his longer-term response to his release demonstrates the divergent experiences and responses to release between players. From the players' retrospective interviews, it was clear to see that each individual's experience of the release process was bespoke and had nuances, and each player responded differently.

### Accepting release

One such individualized aspect the players talked of was varying levels of acceptance over their release, and how this changed over time. Arthur and John took the longest to accept their release, most likely due to long-term injuries they were suffering with, whereas Ben accepted his release sooner. All participants accepted their release in the longer term. Keith took ownership over his release, which resulted in him accepting the club's decision almost immediately following his release:

> "I think 'cos in the back of your mind, you know you're not good enough to be there, especially going into League 1 as well, at the time, so I think I kind of accepted it, like, in my head without knowing I'm accepting it, if that makes sense."

The ownership and acceptance of his release allayed anxiety Keith had when informing others of his "perceived failure" to earn another contract: "Not that bad to be honest. Just it is what it is.. you've got to be honest with them. There's no point lying or.. saying.. or blaming other people. You just say it how it is…". In contrast, Arthur struggled to accept his release initially and discussed whether his psychological difficulty was related to his release or his injury...

> "Erm.. yeah just 'cos of my injury really, 'cos I knew if I hadn't been injured, I would have been made it as a professional footballer or a first team player.. erm.. so it was always in my mind like 'oh what if I didn't get injured?' Or, 'what if I.. what if I.. just didn't train some days?' Or, 'what if I just rested it some days?' Or, 'what if I went.. seen the physio earlier, before my injury?' or something like that."

Arthur subsequently recalled how that made him feel: "Err.. upset… I felt just like… alone all the time, especially with being away from the club.. any club really, and just being around the banter and stuff."

As previously highlighted, Keith expressed far fewer psychosocial difficulties in comparison to the other participants following release. It appeared that Keith experienced less difficulty transitioning away from full-time football due to his ownership over release and acceptance of not being good enough for first-team football. From our interpretation, Keith demonstrated a greater emotional maturity than the other participants when talking about and reflecting on his release. This is possibly due to being older than the other players, but also owing to the fact he had a young family when he was released, thus 'grew up' earlier. In contrast, Arthur lacked acceptance and ownership over his release, and subsequently experienced severe psychological difficulties. His lack of ownership appeared to come from a belief his release was out of his control, due to a major injury, and a belief he would have become an established professional player without this. Keith and Arthur's contrasting levels of acceptance of their release again highlight the divergent experiences players had with their release.

## Support during the process of release

Players discussed aspects of support throughout the release process and how they perceived this to affect their psychological and emotional response to release.

### Club aftercare

All the players reported receiving no support for their wellbeing from their club following their release. This left them feeling sad, angry, and isolated. Arthur recalled the lack of support provided by the club:

> "The club kind of just leave you to it.. which is.. hard because you'd been there for so long. Then they just brush you aside like you're nothing.. which is why.. that's how you know it's more of a business more than.. more than anything.. erm.. so I had to just try and find it myself.. and just work off my own back really."

Keith echoed a perceived lack of support provided by the club:

> "..they give it the old token 'oh if you ever need anything, give me a call', but you never would. It was just kind of off you go and that was it. Just sort yourself out."

All the participants expressed feelings of anger and betrayal, that clubs they had dedicated their lives to for so many years provided them with such little support, adding to the difficulties they experienced during the transition out of professional football. During all the interviews, the lack of perceived aftercare provided by clubs was noticeably a bitter pill for players to swallow and anger was evident in their voices. Despite all the players highlighting the need for support in dealing with the emotional and psychological problems that occurred following their release, Keith's quote revealed a reluctance to reach out to his former club for support, which was echoed by the other players. It was interpreted that former clubs who the players perceived had caused their suffering would be the last place they would seek support from.

## Support from significant others

All the players reported that emotional support was available from their parents but highlighted not wanting to burden their parents with their emotional suffering and difficulties. John spoke of the guilt he felt when the realization of not being able to play again because of injury sank in, due to the sacrifices and commitment his parents had made throughout his football career:

> "The amount they sacrificed, I was more gutted for my Dad that I weren't gonna be able to play again. Then.. it all just

> got way too much and I just broke down 'cos of that. Then.. then I realized I weren't gonna be able to play football."

It was evident during the interview that John was very emotional when talking about the role his parents played in supporting his football career, and one of the factors that distressed him the most following his release was the sadness and guilt he felt at not being able to "repay" his parents' sacrifices by carrying on playing. The lack of social support players sought from family and friends possibly added to the sense of isolation the players felt after being released, compounding the distress they experienced. For John, Arthur, and Ben, by bottling up their emotions and not sharing their struggles with significant others, the emotional turmoil they suffered increased.

All participants highlighted the positive team spirit of their respective youth teams and the strong bonds they developed with other players, describing the team as "like a family." When players and their teammates were released, the participants highlighted the "shared experience" they all went through. Arthur commented:

> "My age group.. I think most of them got released the year before.. which was hard for me 'cos it kind of left us.. like me on my own.. with the younger players.. erm.. but yeah there was a few that got released at the same time as me. We was all going through like a difficult time, which was.. well it was good that we could speak to each other about it and stuff.. erm.. and they.. yeah they were just going through the same thing really."

Throughout the interviews with the players, it became apparent that being released was a "shared experience" with teammates. The players within the present study viewed teammates who had also been released as a valuable support network, especially when compared to their friends outside of football, who they felt found it hard to relate to what they were going through.

## Seeking professional support

Both Arthur and John actively sought help themselves to deal with the psychological and emotional difficulties they were experiencing after being released. Arthur talked about seeking support from the Professional Footballer's Association (PFA):

> "Five months after.. maybe six months after.. I'd left. Erm.. I just remember one day I was just too down and I wasn't doing anything, I wasn't moving out my bed, I wasn't talking to anyone, I wasn't.. I didn't want to be like.. productive or anything. So.. I just.. they'd always told you at football, if

> there's anyone you want to speak to then you can ring the PFA, and I thought I'll just try it.. and it was.. erm.. they sorted me out with someone.. ASAP, like they gave me someone.. I think the next day to speak to, which was good. And I just seen him weekly.. and then as it got better.. you know, you just see him monthly and then you're just seeing him like every other month and then.. so I did that for about.. a year and a half or so.. erm.. I think if I hadn't spoke to anyone, I would have just.. I woulda been just too sad all the time… I spoke to him regular.. so.. and he was just helping me get through the process and stuff.. erm.. so through that time, it was hard, it was difficult, but when you're speaking to someone and letting them know how you feel, and letting your feelings out.. because when you're in a.. like a man environment, in a football environment, nobody really speaks to each other about your feelings like that.. so over time it was difficult but it was getting better."

Although Arthur accessed the counseling services available through the PFA for its members, John accessed

an independent counseling service over a year after he was released whilst undertaking physiotherapy for his long-term knee injury. Arthur felt the PFA provided him excellent support in helping him cope with his psychological difficulties. Similarly, John found the experience of talking to an independent counselor very beneficial in coping with his distress. The benefit players experienced from seeking professional support is salient, and highlights the positive impact aftercare can have on released players if provided by clubs.

## New beginnings—"there's a bigger world than just playing football every day"

Players discussed how they moved on following their release and some of the positive psychosocial outcomes that resulted from the healing process.

### Moving on

All the players felt they could have been better prepared by their clubs for release, but there were contrasting views on how this could be improved. Ben discussed the difficulty of preparing players for being released:

> "No one really.. is ever gonna sit down and like.. have a meeting with you and be like 'ah okay, this is what it's gonna be like when you're released', 'cos no one wants you to be released, so they kind of avoid the subject in all cases, and if it happens.. ah, you know what, it's unfortunate. It's not like,
>
> they have like meetings where.. 'okay, what do you want to do outside of football?'.. It's not like school, 'oh what do you want to do when you leave school?' Like, it's not like that at all. Like, school.. everyone knows they're leaving school, but football, they kind of avoid the fact that people do get released and the shit side of it."

Ben's quote highlights the difficulty for clubs in trying to prepare players for being released. Possibly providing a solution to this problem, Arthur expressed a desire to try and help current youth players prepare for the possibility of being released:

> "Yeah I said that to the person from the PFA. Obviously he.. I spoke to him about my like stuff, and my feelings and stuff, and he said to me 'oh why don't you go and.. go into clubs and talk about that?' And I said, 'yeah I would like to do that, I just need to look into it a bit more'. But if that opportunity came up, I'd definitely do that.. 'cos the word needs to get out more.. and more people need to know and youngsters.. like now I know a few players that have just been released this season and I can see it in their face, like.. how down they were but they don't say anything about it. But yeah, I'd definitely do that if I could."

This quote highlights the cathartic nature of both Arthur's counseling experience and the research interview. Initially, Arthur would not have been able to talk about his experiences because of the initial emotional trauma, but over time he has demonstrated his openness to new possibilities.

### Growth after release

A positive that all participants talked about during their interviews was an increased psychological resilience following their release, stemming from an enhanced sense of personal strength. John stated: "You literally work so hard for everything that literally gets ripped away from you, I think to go through all that.. I don't think there's anything I'll struggle with mentally after that." Both John and Arthur were released due to injury, which ultimately led to their retirement from football. Upon coming to terms with their release, the players talked of looking forward, and their plans for the future. Arthur stated:

> "..but now I look at it and think.. like I do miss football but.. it's only a short term thing.. erm.. and like the world's massive, like.. there's a bigger world than just playing football every day and.. there's so much more to do, and so much more to see, and.. like I said football's restricted, you can't do certain things, like with your friends and stuff. You miss
>
> quite a few.. like just social time.. which I can do now and I think, you feel more like, free."

Arthur's quote, "there's a bigger world than just playing football every day," highlights the existential accounts given by the players regarding their experiences of the release process. For Arthur, having a newfound freedom, from both a high, foreclosed athletic identity and the "all-consuming football environment", has allowed him to develop a new outlook on life and view of his personal world. Following the healing process of coming to terms with being released, and in Arthur and John's case, not being able to play football again, the participants have begun to construct new identities for themselves. Whereas the other participants have, at the least, constructed partial new identities, Ben still clings to his identity as a footballer, and is determined to re-enter full-time football. If he does not re-enter full-time football, this may be problematic to his long-term development, as holding on to his athletic identity may reduce his ability to build a new identity, potentially putting his life on hold.

## Discussion

This study was the first to qualitatively explore players' experiences of release from professional football academies. The four players, John, Arthur, Ben, and Keith all interpreted their release differently, but all viewed the release itself as a traumatic experience. For instance, all four players recalled almost identical contract meeting experiences: being gathered in the changing rooms and called one-by-one to their contract meetings, before returning to the changing room having learnt their fate, which caused them to feel shamed, embarrassed, and humiliated in front of their teammates.

A salient finding of the present study was the interpretation of release as a process, rather than a singular event, through the players' stories and experiences. This finding supports previous research that sport retirement is a process as opposed to an isolated event and extends knowledge in this area as release is a non-normative transition relative to athletic retirement at the end of an athlete's career (Taylor and Ogilvie, 1994). This process began with release being foreshadowed by the marginalization of players in the lead up to contract meetings. We interpreted the players immediate responses to release after their contract meeting as emotionally traumatic—characterized by the players' repeated use of the word "horrible". Although some caution needs to be applied when associating players' release with trauma, in psychology, trauma is based on a person's subjective interpretation of an event rather than the objective characteristics or consequences of the event (Joseph, 2011). A defining aspect of trauma is the event causing physical or emotional harm, leading people to challenge assumptions about themselves and the world in which they live (Janoff-Bulman, 1992). The contract meeting causing emotional harm was clearly demonstrated by John, and Keith candidly captured how his release led him to challenge all his prior assumptions about himself and his world—"from everything to nothing in a split second".

In the longer term, John, Arthur and Ben experienced psychological difficulties due to their release, including feelings of depression, anxiety, identity crisis and loss of self-worth, low esteem and confidence, which is supported by previous research (Blakelock et al., 2016). For these players, their most severe psychological and emotional distress was delayed, and experienced some time after the event of release. This supports the idea that release was not just a one-off moment, rather a process, for these players. It appears the effects being released has on players may not be experienced fully at the time of release, but after a delayed response—years in some cases, extending previous research (Brown and Potrac, 2009; Blakelock et al., 2016, 2019).

The individualized nature of the experience of the release process was also evident in the divergent psychological and emotional response to release between players. Specifically, it appeared as though levels of acceptance over their release affected the players' psychological and emotional response, as demonstrated by Keith and Arthur. As Keith took ownership over his release due to a perceived lack of ability, he may have begun preparing psychologically for release, thus appraising it as less harmful and threatening, reducing distress (Blakelock et al., 2019). This appraisal of release was also helped by the fact he transitioned into full-time non-league football, adding to his sense of perceived control of his situation. This is an example of problem-focused coping that has previously been shown to reduce psychological distress in released youth footballers (Blakelock et al., 2019). He also stated positive psychosocial outcomes as a result of his release such as re-finding his love for football. In contrast, Arthur perceived he had very limited control over his release, due to a long-term injury, and was thrust out of professional football unexpectedly and suddenly. This may have led him to appraise release as particularly harmful, increasing the psychological distress experienced (Blakelock et al., 2016, 2019). The wishful thinking and denial Arthur discussed in relation to accepting his release are indicative of avoidance coping strategies, which have been shown to increase psychological distress in released youth footballers (Blakelock et al., 2019).

A salient finding from the present study was the severe psychological difficulties experienced by those players who perceived that their release was injury related. Both Arthur and John suffered long-term injuries before they were released and reported experiencing severe levels of distress for a long time after their release, culminating in their forced retirements from football. This supports previous findings of the psychological difficulties athletes encounter through injury enforced retirement (Wippert and Wippert, 2010; Park et al., 2013; Arvinen-Barrow et al., 2017). The perceived lack of control both injured players had in relation to their release might be a factor in the magnitude of the psychological distress they experienced. Previous research suggests that athletes are more likely to experience emotional disturbance and psychological distress when their career is terminated involuntarily than athletes who have autonomy over career termination (Warriner and Lavallee, 2008; Wippert and Wippert, 2008; Park et al., 2013). This is consistent with findings from the present study and extends previous research into the area of elite youth football.

Despite being an obviously negative experience for players, the psychosocial problems related to release appeared to be compounded for players in this study by a series of factors. Firstly, the unpredictable nature of the professional football academy environment may not be conducive to a healthy transition out of academy football. Players reported feelings of helplessness, and a lack of control within the academy environment, which compliments previous research (Roderick, 2006; Sagar et al., 2010; Nesti and Sulley, 2013). This was typified by Keith's quote referring to his amotivation in the lead up to his release; a psychological state in which a person lacks

either self-efficacy or a sense of control when striving to attain a desired outcome (Ryan and Deci, 2000). Conforming dedication to football has previously been stated as a psychosocial trait associated with progression to senior professional football (Holt and Dunn, 2004). However, as Keith outlined, if the reward for displaying these behaviors is not perceived to be there, players may not act in a volitional manner or display this conforming dedication. All the players also highlighted instances of being marginalized before being released, which foreshadowed the players' fates. After they were released, whilst they were still training with their club, they were "left out in the cold". This public embarrassment and humiliation in front of teammates the players discussed led to feelings of hurt and shame. Shame is a painful emotion that is associated with feelings of inadequacy and the perception that one's entire self is a failure (Lewis, 1992). Previous research has highlighted that being released is viewed by players as failure and they are highly fearful of this outcome (Sagar et al., 2010). This demonstrates how the immediate emotional trauma of release was exacerbated for the players in the days following their contract meeting; being dehumanized and made to feel worthless by clubs they had dedicated large portions of their life to.

Another factor that likely compounded the psychological difficulties experienced by the players was reduced social support following release. Social support refers to "social interactions aimed at inducing positive outcomes," (Bianco and Eklund, 2001, p. 85) with previous research showing its importance in positive sporting career transitions (Park et al., 2013). Players reported receiving limited aftercare from their professional clubs following their release, leaving them feeling hurt, angry and with a sense of betrayal. The lack of aftercare provided by clubs contributed to the problematic transitions experienced by the players, which is supported by previous research (Brown and Potrac, 2009; Wilkinson, 2021). It is important to note, despite the perceived lack of support the players were provided by their clubs, Keith commented on the reluctance players might feel in reaching out to a club they were released by for support. There may be a disparity in the perceived available and received support to players, which typically refers to the frequency with which an individual has received supportive resources during a specific time frame (Gottlieb and Bergen, 2010). This suggests further discussions around what support released players would benefit from is warranted and highlights the challenges clubs face in terms of release aftercare.

Players did not seek support from their parents due to feeling guilty about letting their parents down and not wanting to burden them with their problems, despite perceiving that their parents' support would be readily available to them (Freeman, 2020). This seemed to lead to John, Arthur, and Ben bottling up their emotions, which may have been a factor in the longer-term psychosocial problems they experienced. Previous research has highlighted the benefits of players using their parents as a source of support during the deselection process (Neely et al., 2017). However, the players in the current study were older than the athletes in the Neely et al. (2017) study - a key difference as to why the parents of the players in the present study were not as involved in their son's careers. This was evident through the players not needing tangible support such as transport to training and games, and in some cases living away from their home in "digs" (Freeman, 2020). Interestingly, the players reported sharing the experience of release with their teammates, who were viewed as a positive source of support both before and after the players were released (Neely et al., 2018).

A novel finding of the present study was the positive psychosocial outcomes in the players following their release, which have not been previously shown in the unique context of elite youth football. Although release was described as a negative experience, all the players discussed positive personal development following their release. The openness to new possibilities outlined by Arthur, and the perceived increase in personal strength John noted, are characteristics of posttraumatic growth; defined as experiencing positive change as a result of the struggle with major life crises (Tedeschi and Calhoun, 1995). All the players spoke about aspects associated with posttraumatic growth, including an appreciation of life, and relating to others. The players appeared to experience posttraumatic growth sometime after their release, consistent with previous research (Neely et al., 2018). The healing process following release has allowed Arthur to develop a new outlook on life and view of his personal world (Athens, 1995). Keith and Arthur poignantly captured how the process of release affected the players' sense of belonging in the world, and candidly demonstrates the existential meaning players placed on their release (Nizza et al., 2021). This extends previous research showing former academy cricket and rugby players developed positive psychological characteristics during their time on the development pathway that supported their transition into other domains following deselection (Knights et al., 2016; Williams and MacNamara, 2020).

## Applied implications

Release from professional academy football can be a traumatic experience and lead to long-term psychological difficulties. Our findings highlight opportunities for players, clubs and key stakeholders to consider how the release process is handled. Throughout the release process, players experienced feelings of a lack of control and often displayed maladaptive coping strategies. Academies could develop pre-release programs aimed at preparing players for release by developing a series of psychosocial skills, which could support their transition out of football. This could include developing coping skills, improving their ability to seek social support, developing their confidence and self-esteem, and increasing autonomy (Williams and MacNamara, 2020).

As part of this preparatory program, previously released players could volunteer to talk to players at professional academies about their experiences of being released, as Arthur suggested in our study. This finding is noteworthy, as the insight and lived experiences of the process from released players would be valuable for current players in preparing them for release, especially with regards to championing their positive experiences of seeking support from counseling services following their release. If there is more realism from players and coaches, accepting the likelihood that becoming a professional is very slim, they may begin to prepare for a potential transition. Interestingly, Keith reported being repeatedly made aware of the high percentage of players who do not become professionals. This realism from the club, although possibly harsh for players to hear, may allow players to begin the appropriate career planning associated with healthy career transition. If the subject of release is avoided by clubs, as with Ben's experience, combined with the fact players suggested they focused all their efforts on becoming a professional footballer, and any thought otherwise was dismissed, the likelihood of a problematic transition increases (Brown and Potrac, 2009).

Through an IPA approach we revealed that players may experience the release process differently. Therefore, an individualized approach to supporting player transition out of academies is warranted. This includes considering the player's perceptions of the potential reasons for their release, and thus their levels of acceptance, with our study suggesting that players who are released through injury or with a long-term injury should be identified as potentially needing greater support. This is supported by previous research, with 11 counselors who work for the PFA suggesting that deselection and forced retirement through injury was traumatic for players (Gervis et al., 2019).

As some players struggled with mental health problems following their release, improvements in provision for player aftercare following release are warranted, including formalized professional support. Recently, Crystal Palace Football Club have announced an aftercare programme to support players released from their academy between the ages of 18–23, which is a vital step forward (Crystal Palace Football Club, 2022). In the present study, Arthur benefitted from PFA counseling sessions once he sought support. However, it is unclear how many released youth footballers are unaware of this service—or are not accessing it. Thus, the benefit of using PFA counseling services could be promoted and encouraged for all released scholars. All released players that are members of the PFA could be scheduled in for an initial counseling session with the PFA's counseling network by their clubs, which the players could continue with if they feel it is beneficial. This supports a recent review calling for clubs to offer released players counseling during the transition away from the club and beyond (Wilkinson, 2021).

## Strengths and limitations

Our study gained valuable insight into the processes involved with release from academy football, being the first study to qualitatively explore players' experiences of the release process. We presented novel findings that: release is a process and individualized to each player, release with a long-term injury can result in more psychological difficulties and in the longer-term players develop positive psychosocial outcomes. This expands current knowledge and understanding in a hard-to-reach population. A further strength was the caliber of participant recruited, and the levels of football they have played at. Nevertheless, a potential limitation was the use of retrospective interviews, due to potential memory decay and a bias around players' memories of their experiences. Yet, these fading effects are reduced regarding momentous events, such as a player's release (Pillemer, 2001). It also allowed the players' growth since their release to be explored, with them reflecting on their release both at the time and retrospectively.

## Future research

One possible direction for future research is exploring the experiences of academy staff members involved in the release process and understanding their perspectives on the process. This may shed further light on how coaches feel they prepare players for release, possibly through foreshadowing their fate and marginalizing players. This would provide further understanding in the area from a different key stakeholder. Further future research should look to explore players' experiences of release "live" at the time of selection procedures. A prospective longitudinal study over an extended period would be a useful avenue for future research, exploring players' perceptions prior to, at the time of, and post release. Furthermore, players' divestment of athletic identity following release, or as in Ben's case, the reinforcement of this identity should be explored further to understand the longer-term impacts of this. As noted in the present study, positive growth and outcomes were highlighted by the players and further study will aid the knowledge of this.

## Conclusion

To our knowledge, this study was the first to qualitatively explore elite youth footballers' experiences of release. Players reported a range of psychosocial effects associated with their release, and limited aftercare following their release, which affected the quality of their transition away from full time football. Through a qualitative, IPA approach, the present study adds in depth knowledge and understanding of both the release process, and the lived experiences of elite youth released footballers, to the literature.

## Data availability statement

The datasets presented in this article are not readily available because it's not possible to share the interview data as the interviews contain information that could be identifiable. Requests to access the datasets should be directed to tom.mcglinchey@ntu.ac.uk.

## Ethics statement

The studies involving human participants were reviewed and approved by the Non-Invasive Ethical Review Committee, School of Science and Technology, Nottingham Trent University. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

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

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

Arvinen-Barrow, M., Hurley, D., and Ruiz, M. C. (2017). Transitioning out of professional sport: The psychosocial impact of career-ending injuries among elite Irish rugby football union players. *J. Clin. Sport Psychol.* 11, 67–84. doi: 10.1123/jcsp.2016-0012

Athens, L. H. (1995). Dramatic self change. *Sociol. Q.* 36, 571–586. doi: 10.1111/j.1533-8525.1995.tb00454.x

Bianco, T., and Eklund, R. C. (2001). Conceptual considerations for social support research in sport and exercise settings: The case of sport injury. *J. Sport Exerc. Psychol.* 23, 85–107. doi: 10.1123/jsep.23.2.85

Blakelock, D. J., Chen, M. A., and Prescott, T. (2016). Psychological distress in elite adolescent soccer players following deselection. *J. Clin. Sport Psychol.* 10, 59–77. doi: 10.1123/jcsp.2015-0010

Blakelock, D. J., Chen, M. A., and Prescott, T. (2019). Coping and psychological distress in elite adolescent soccer players following professional academy deselection. *J. Sport Behav.* 42, 3–28.

Brocki, J. M., and Wearden, A. J. A. (2006). Critical evaluation of the use of interpretative phenomenological analysis (IPA) in health psychology. *Psychol. Health* 21, 87–108. doi: 10.1080/14768320500230185

Brown, C. J., Webb, T. L., Robinson, M. A., and Cotgreave, R. (2018). Athletes' experiences of social support during their transition out of elite sport: An interpretive phenomenological analysis. *Psychol. Sport Exerc.* 36, 71–80. doi: 10.1016/j.psychsport.2018.01.003

Brown, G., and Potrac, P. (2009). 'You've not made the grade, son': De-selection and identity disruption in elite level youth football. *Soccer Soc.* 10, 143–159. doi: 10.1080/14660970802601613

Brownrigg, A., Burr, V., Locke, A., and Bridger, A. J. (2012). You don't know what's around the corner: A qualitative study of professional footballers in England facing career-transition. *Qual. Methods Psychol. Bull.* 14–23.

Calvin, M. (2017). *No Hunger in Paradise: The players. The Journey. The Dream*. New York, NY: Random House.

Champ, F. M., Nesti, M. S., Ronkainen, N. J., Tod, D. A., and Littlewood, M. A. (2020). An exploration of the experiences of elite youth footballers: The impact of organizational culture. *J. Appl. Sport Psychol.* 32, 146–167. doi: 10.1080/10413200.2018.1514429

Crystal Palace Football Club (2022). Available from: https://www.cpfc.co.uk/news/club/crystal-palace-enhances-after-care-programme-for-released-academy-players/2022-01-29/ (accessed May 10, 2022).

Erpič, S. C., Wylleman, P., and Zupančič, M. (2004). The effect of athletic and non-athletic factors on the sports career termination process. *Psychol. Sport Exerc.* 5, 45–59. doi: 10.1016/S1469-0292(02)00046-8

Freeman, P. (2020). "Social support in sport," in *Handbook of Sport Psychology*, 1st *Edn*, eds G. Tenenbaum and R. C. Eklund (Hoboken, NJ: Wiley), 447–463. doi: 10.1002/9781119568124.ch21

Gervis, M., Pickford, H., and Hau, T. (2019). Professional footballers' association counselors' perceptions of the role long-term injury plays in mental health issues presented by current and former players. *J. Clin. Sport Psychol.* 13, 451–468. doi: 10.1123/jcsp.2018-0049

Gledhill, A., Harwood, C., and Forsdyke, D. (2017). Psychosocial factors associated with talent development in football: A systematic review. *Psychol. Sport Exerc.* 31, 93–112. doi: 10.1016/j.psychsport.2017.04.002

Goldberg, D., and Williams, P. A. (1988). *A User's Guide to the General Health Questionnaire*. London: NFER-Nelson.

Gottlieb, B. H., and Bergen, A. E. (2010). Social support concepts and measures. *J. Psychosom. Res.* 69, 511–520. doi: 10.1016/j.jpsychores.2009.10.001

Green, C. (2009). *Every Boy's Dream: England's Football Future on the Line*. London: A&C Black.

Heidegger, M. (1962). *Being and Time*. Oxford: Blackwell Publishers.

Holt, N. L., and Dunn, J. G. (2004). Toward a grounded theory of the psychosocial competencies and environmental conditions associated with soccer success. *J. Appl. Sport Psychol.* 16, 199–219. doi: 10.1080/10413200490437949

Holt, N. L., and Mitchell, T. (2006). Talent development in English professional soccer. *Int. J. Sport Psychol.* 37, 77.

Honebein, P. C. (1996). "Seven goals for the design of constructivist learning environments," in *Constructivist Learning Environments: Case Studies in Instructional Design*, ed B. G. Wilson (Englewood Cliffs, NJ: Educational Technology Publications), 11–24.

Janoff-Bulman, R. (1992). *Shattered Assumptions: Towards a New Psychology of Trauma*. New York, NY: Free Press.

Joseph, S. (2011). *What Doesn't Kill Us: The New Psychology of Posttraumatic Growth*. Basic Books.

Knights, S., Sherry, E., and Ruddock-Hudson, M. (2016). Investigating elite end-of-athletic-career transition: A systematic review. *J. Appl. Sport Psychol.* 28, 291–308. doi: 10.1080/10413200.2015.1128992

Lally, P. (2007). Identity and athletic retirement: A prospective study. *Psychol. Sport Exerc.* 8, 85–99. doi: 10.1016/j.psychsport.2006.03.003

Langdridge, D. (2007). *Phenomenological Psychology: Theory, Research and Method*. London: Person Education Limited.

Larkin, P., and Reeves, M. J. (2018). Junior-elite football: Time to re-position talent identification? *Soccer Soc.* 19, 1183–1192. doi: 10.1080/14660970.2018.1432389

Lewis, M. (1992). *Shame: The Exposed Self*. New York, NY: Free Press.

Marshall, C., and Rossman, G. B. (2015). *Designing Qualitative Research, 6th Edn*. Thousand Oaks, CA: SAGE.

Mitchell, T., Gledhill, A., Nesti, M., Richardson, D., and Littlewood, M. (2020). Practitioner perspectives on the barriers associated with youth-to-senior transition in elite youth soccer academy players. *Int. Sport Coach. J.* 7, 273–282. doi: 10.1123/iscj.2019-0015

Mitchell, T. O., Nesti, M., Richardson, D., Midgley, A. W., Eubank, M., Littlewood, M., et al. (2014). Exploring athletic identity in elite-level English youth football: A cross-sectional approach. *J. Sports Sci.* 32, 1294–1299. doi: 10.1080/02640414.2014.898855

Neely, K. C., Dunn, J. G., McHugh, T. L., and Holt, N. L. (2018). Female athletes' experiences of positive growth following deselection in sport. *J. Sport Exerc. Psychol.* 40, 173–185. doi: 10.1123/jsep.2017-0136

Neely, K. C., McHugh, T. L., Dunn, J. G., and Holt, N. L. (2017). Athletes and parents coping with deselection in competitive youth sport: A communal coping perspective. *Psychol. Sport Exerc.* 30, 1–9. doi: 10.1016/j.psychsport.2017.01.004

Nesti, M., and Littlewood, M. (2011). "Psychological preparation and development of players in premiership football: Practical and theoretical perspectives," in *International Research in Sciences and Soccer*, eds T. Reilly, A. Williams, and B. Drust (London: Routledge).

Nesti, M., and Sulley, C. (2013). *Youth Development in Football: Lessons From the World's Best Professional Clubs*. London: Routledge.

NICE. (2011). *Commissioning Stepped Care for People With Common Mental Health Disorders*. London: National Institute for Health and Clinical Excellence.

Nizza, I. E., Farr, J., and Smith, J. A. (2021). Achieving excellence in interpretative phenomenological analysis (IPA): Four markers of high quality. *Qual. Res. Psychol.* 18, 369–386. doi: 10.1080/14780887.2020.1854404

Park, S., Lavallee, D., and Tod, D. (2013). Athletes' career transition out of sport: A systematic review. *Int. Rev. Sport Exerc. Psychol.* 6, 22–53. doi: 10.1080/1750984X.2012.687053

Patton, M. Q. (2015). *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*, 4th Edn. Thousand Oaks, CA: Sage.

Pillemer, D. B. (2001). Momentous events and the life story. *Rev. Gen. Psychol.* 5, 123–134. doi: 10.1037/1089-2680.5.2.123

Premier League. (2012). *The Elite Player Performance Plan*. London.

Rai, D., Kosidou, K., Lundberg, M., Araya, R., Lewis, G., Magnusson, C., et al. (2012). Psychological distress and risk of long-term disability: Population-based longitudinal study. *J. Epidemiol. Community Health*. 66, 586–592. doi: 10.1136/jech.2010.119644

Relvas, H., Littlewood, M., Nesti, M., Gilbourne, D., and Richardson, D. (2010). Organizational structures and working practices in elite European professional football clubs: Understanding the relationship between youth and professional domains. *Eur. Sport Manag. Q.* 10, 165–187. doi: 10.1080/16184740903559891

Richardson, D., Gilbourne, D., and Littlewood, M. (2004). Developing support mechanisms for elite young players in a professional soccer academy: Creative reflections in action research. *Eur. Sport Manag. Q.* 4, 195–214. doi: 10.1080/16184740408737477

Roderick, M. J. (2006). *The Work of Professional Football: A Labour of Love?*. London: Routledge.

Roe, C., and Parker, A. (2016). Sport, chaplaincy and holistic support: The elite player performance plan (EPPP) in English professional football. *Pract. Theol.* 9, 169–182. doi: 10.1080/1756073X.2016.1221638

Ryan, R. M., and Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*. 55, 68. doi: 10.1037/0003-066X.55.1.68

Sagar, S. S., Busch, B. K., and Jowett, S. (2010). Success and failure, fear of failure, and coping responses of adolescent academy football players. *J. Appl. Sport Psychol.* 22, 213–230. doi: 10.1080/10413201003664962

Smith, B., and McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology. *Int. Rev. Sport Exerc. Psychol.* 11, 101–121. doi: 10.1080/1750984X.2017.1317357

Smith, J. A., and Osborn, M. (2004). "Interpretative phenomenological analysis," in *Doing Social Psychology Research*, ed G. M. Breakwell (Oxford: Blackwell Publishing), 229–254.

Stambulova, N., Alfermann, D., and Statler, T. (2009). CôTé JE. ISSP position stand: Career development and transitions of athletes. *Int. J. Sport Exerc. Psychol.* 7, 395–412. doi: 10.1080/1612197X.2009.9671916

Taylor, J., and Ogilvie, B. C. A. (1994). conceptual model of adaptation to retirement among athletes. *J. Appl. Sport Psychol.* 6, 1–20. doi: 10.1080/10413209408406462

Tedeschi, R. G., and Calhoun, L. G. (1995). *Trauma and Transformation: Growing in the Aftermath of Suffering*. Thousand Oaks, CA: Sage.

Tracy, S. J. (2010). Qualitative quality: Eight "big-tent" criteria for excellent qualitative research. *Qual. Inq.* 16, 837–851. doi: 10.1177/1077800410383121

Warriner, K., and Lavallee, D. (2008). The retirement experiences of elite female gymnasts: Self identity and the physical self. *J. Appl. Sport Psychol.* 20. doi: 10.1080/10413200801998564

Webb, T., Dicks, M., Brown, D. J., and O'Gorman, J. (2020). An exploration of young professional football players' perceptions of the talent development process in England. *Sport Manag. Rev.* 23, 536–547. doi: 10.1016/j.smr.2019.04.007

Webb, W., Nasco, S., Riley, S., and Headrick, B. (1998). Athlete identity and reactions to retirement from sports. *J. Sport Behav.* 21, 338–362.

Wilkinson, R. J. A. (2021). A literature review exploring the mental health issues in academy football players following career termination due to deselection or injury and how counselling could support future players. *Counsell. Psychother. Res.* 21, 859–868. doi: 10.1002/capr.12417

Williams, G., and MacNamara, Á. (2020). "I Didn't Make It, but…": Deselected athletes' experiences of the talent development pathway. *Front. Sports Act. Living* 2, 24. doi: 10.3389/fspor.2020.00024

Wippert, P. M., and Wippert, J. (2008). Perceived stress and prevalence of traumatic stress symptoms following athletic career termination. *J. Clin. Sport Psychol.* 2, 1–6. doi: 10.1123/jcsp.2.1.1

Wippert, P. M., and Wippert, J. (2010). The effects of involuntary athletic career termination on psychological distress. *J. Clin. Sport Psychol.* 4, 133–149. doi: 10.1123/jcsp.4.2.133

Wylleman, P., and Lavallee, D. (2004). "A developmental perspective on transitions faced by athletes," in *Developmental Sport and Exercise Psychology: A Lifespan Perspective*, eds M. R. Weiss (Morgantown, WV: Fitness Information Technology), 507–527.

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# A survey of organizational structure and operational practices of elite youth football academies and national federations from around the world: A performance and medical perspective

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**Aim:** Medical and performance units are integral components of player development programmes in elite football academies. Nevertheless, the nature of the operational processes implemented by practitioners within clubs and national federations remains unexplored. The aim of the present study, therefore, was to survey elite youth professional football academies from around the world regarding the operational processes adopted by their medical and performance units.

**Methods:** Of the 50 organizations invited, 10 national federations and 25 clubs took part in the survey resulting in a response rate of 70% (95% confidence interval, 56%–81%). The respondents represented three groups: senior club and academy management, performance, and medical staff.

**Results:** The majority (60%–90%) of clubs and national federations reported strategic alignment between senior and academy medical and performance units as well as between academy medical and performance units. Survey responses indicated substantial heterogeneity in the composition and number of medical and performance professionals employed in academies. The majority of respondents agreed their medical and performance departments were effective in utilizing staff knowledge and external sources of knowledge to inform their practice (56%–80%). Performance staff (40%–50%) and physiotherapists (30%–32%) were deemed most influential in injury

prevention programmes. During the return-to-play process, the influence of specific practitioners in the medical and performance units was dependent upon the phase of return-to-play. Shared decision-making was common practice amongst performance and medical staff in injury prevention and return-to-play processes. Medical and performance data were generally centralized across the first team and academy in majority (50%–72%) of clubs and national federations. Data were integrated within the same data management system to a higher degree in clubs (68%) vs. national federations (40%). Research and development activity were reported for most academies (50%–72%), and generally led by the head of performance (37%) or team doctor (21%). Research activities were largely undertaken *via* internal staff (~100%), academic collaborations (50%–88%) and/or external consultants and industry partnerships (77%–83%) in the national federation and clubs.

**Conclusion:** Collectively, these findings provide a detailed overview regarding key operational processes delivered by medical and performance practitioners working in elite football academies.

KEYWORDS

**player development, strategy, process management, knowledge management, decision-making, research, innovation**

# Introduction

Professional football clubs and national football federations must remain competitive on both a sport and financial level in order to be effective and successful within the growing sports industry (1, 2). The combined efforts of all relevant stakeholders will impact the ability of clubs and national federations to achieve their strategic objectives (1, 3). In this context, the organization may benefit from enhanced performance of their stakeholders through more effective and efficient management practices, with a particular reference to organizational structure and operational processes (2–6). Given the significant cost of recruiting elite footballers in the transfer market, investment in youth academies, talent identification and development is increasing in strategic importance for many football clubs around the world (7). As key stakeholders in the long-term development of players, the effectiveness of academy and national federation medical and performance departments is, therefore, likely to gain in importance for maximizing the player development (7, 8).

Frameworks for athlete development typically attempt to combine both best practice and experience underpinned by high-quality up-to-date research (9, 10). Research in football generally seeks to provide evidence regarding the value and application of business solutions addressing technical, tactical, physical, and psychological components of football performance, thereby supporting practitioners to make evidence-based decisions on the practices they may employ within an applied setting (8). Conversely, with concrete characterizations provided by research from other sports in mind (6, 11), there is limited information regarding the organizational structures and operational practices adopted by medical and performance departments as they strive to maximize their service provision support to players (2, 8). It seems logical to assume diversity in the strategies applied in practice within modern football organizations across the world, and probably due in part to differences in financial resources as well as cultural influences across different countries (2). However, an understanding of common professional practices is of interest to the clubs, federations, individual practitioners, and researchers since it can support identifying specific areas that may warrant further scrutiny as part of strategies adopted by football organizations to drive competitive advantage.

We therefore aimed to gather information regarding the organizational structure and operational practices of medical and performance departments in elite youth academies and national football federations from around the world. Specifically, we intended to provide a detailed overview in relation to the following areas of elite practice: strategy and structure, knowledge management processes, injury prevention and return-to-play processes, data management processes and research and development activities.

# Materials and methods

## Survey design and distribution

We conducted a cross-sectional survey to gather information on perceptions of staff members regarding organizational structure and operational practices at their

TABLE 1 The types of questions used in the survey.

| Question type | Definition |
|---|---|
| Multiple choice | Choose one answer from list of answers |
| Simple multiple choice | Choose one answer from list of two: yes or no |
| Checkboxes | Select multiple answers from list of answers |
| Single textbox | Write numerical answer to question |
| Ranking | Rank a list of options in order of preference using a numeric dropdown list |
| Matrix/rating scale | Evaluate one or more items using a Likert rating scale (1–7) to assign weights to each answer |

club academies. The survey was developed by a panel of 10 experts with five or more years of experience working in professional football at European and Middle-Asian youth academies. Published work in this (2, 12–14) and other research fields (4) informed the survey design (Table 1) consisting of questions covering specific areas: (1) background information (six items), (2) academy strategy (five items), (3) academy structure (nine items) [5], (4) knowledge management (eight items) [5], return to play (seven items), injury prevention (nine items), data management (six items), and research and development (five items), respectively. The underlying structure of club and federation academies was examined according to the organizational structure frameworks described by Steiger et al. (4) and Mintzberg (15). The return-to-play process was broken down into specific sub-phases (16). The return- to-training sub-phase refers to the gradual re-introduction of the injured player from non-contact to resuming full team training. The return-to-competition sub-phase involves the player's progression in terms of competitive match minutes, whereas in return-to-performance sub-phase the player is deemed to meet the required competition demands (16).

The final survey version (Supplementary File 1) was reviewed for content validity by a group involving two practitioners having previously worked in two English Premier League clubs and one academic with expertise in this area of research. Questions involved multiple choice, simple multiple choice (yes/no), checkbox, numerical, or ranking formats (Table 1). The survey was created using the online software SurveyMonkey® (Momentive Inc., USA), and disseminated to organization representatives *via* an email containing instructions on survey purpose, followed by instructions for survey completion. Importantly, respondents were advised to have relevant information available prior to taking part in the survey. In this context, fifty members of a community of practice led by the lead institution (Aspire Academy) were contacted to take part in the present study (7). Of these, 35 practitioners from individual clubs ($n$ = 25) and national federations ($n$ = 10) agreed to participate in the survey. The 25 clubs were from Europe ($n$ = 19; Austria, Belgium, England, France, Italy, Netherlands, Portugal, Russia, Spain, Switzerland, Ukraine), North America ($n$ = 2; United States of America), South America ($n$ = 3; Argentina, Brazil, Chile), and Africa ($n$ = 1; Tunisia). The 10 national federations were from Europe ($n$ = 3; England, France, Italy), North America ($n$ = 2; Honduras, Mexico), South America ($n$ = 2; Argentina, Chile), Africa ($n$ = 1; South Africa), and Asia ($n$ = 2; Qatar, South Korea). The survey opened on 16/11/2020 and closed on 24/02/2021. This study was approved by the Aspire Zone Foundation Institutional Review Board, Doha, State of Qatar (protocol number: E202007005).

## Statistical analysis

Results were presented as descriptive statistics (17) by organization type. Frequency analysis was conducted for participant characteristics, multiple choice, checkboxes, ranking, Likert-type, and rating scale questions, with the results presented as percentage of respondents and frequency count. The response rate was determined as the number of clubs and national federations respondents who answered by the total number of organizations we invited to take part in the survey, with the Agresti-Coull method (18) used to describe the uncertainty in this estimate expressed as an approximate 95% confidence interval (95% CI). Qualitative terms were also assigned to determine the magnitude of the observed frequencies as follows: All = 100% of respondents; Most = ≥75%; Majority = 55%−75%; Approximately half = ∼50%; Approximately a third = ∼30%; Minority = <30% (7). Responses involving a numerical answer in single questions (i.e., count data) were presented as median plus interquartile range (IQR) or minimum and maximum values. All statistical analyses were performed using R (version 3.6.3, R Foundation for Statistical Computing).

# Results

## Respondents

Of the 50 organizations invited, 10 national federations and 25 clubs agreed to take part in the survey. The response rate was 70% (95%CI, 56%−81%). Among the 25 club respondents, three were technical directors, three academy directors, three director/head of medical and performance, 11 director/head of performance, one medical doctor, three strength and conditioning coaches and one psychologist. Club respondents had worked at their current clubs for 5 years (IQR, 2–9 years), with 10 years (IQR, 6–18 years) of experience in professional football. Of these, 20% had a PhD degree, 40% a Master degree, and 28% a Bachelor degree.

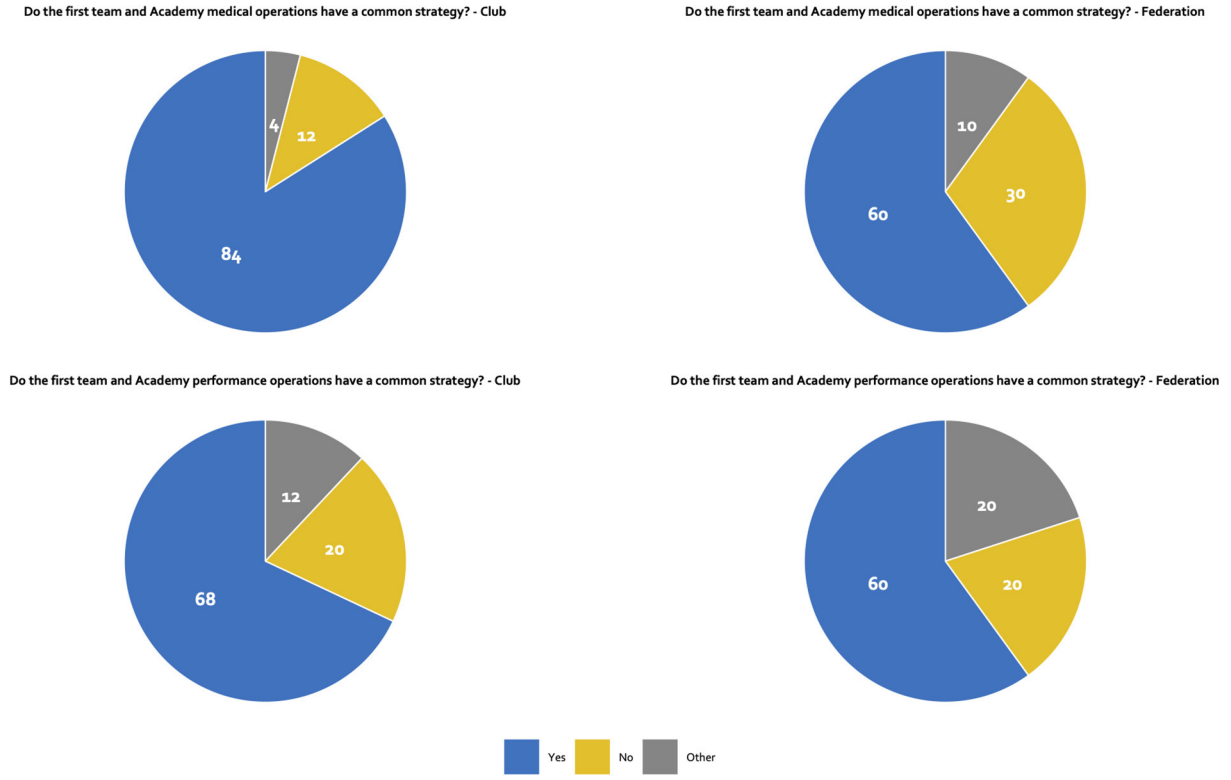


FIGURE 1
Strategy.

Amongst the 10 national federation respondents, two were heads of performance, three team coordinators, one medical doctor, one sport scientist, two strength and conditioning coaches, and 1 head of talent identification. Half of the respondents had a PhD degree, 13 years (IQR, 6–22 years) of experience in professional football, and 3.5 years (IQR, 1–5 years) spent at their respective organization.

## Strategy

The majority of the club respondents stated that the first team and academy medical (84%) and performance (68%) operations are strategically aligned, with medical staff overseeing academy medical operations reporting to those overseeing the first team (Figure 1). Almost all clubs stated that academy medical and performance strategies are aligned (∼90%), with only a third of the clubs' medical and performance operations led by the same individual (∼40%).

The majority (60%) of national federations respondents indicated alignment between the first team and academy medical and performance operations (Figure 1). Likewise, staff members overseeing the medical strategy report to first team staff in most of the national federations (∼60%). Almost all respondents indicated an alignment between medical and performance strategies (∼90%), with the same individual leading both areas in ∼50% of the federations surveyed.

## Structure

The majority (∼60%) of club and national federation respondents agreed with the statement their academies' organization "is defined by its standardization. Work is very formalized, there are many routines and procedures, decision-making is centralized, and tasks are grouped by professional departments. Our roles are clearly defined. We have a formal planning process with budgets and audits, (internal or external) and procedures are regularly appraised for efficiency" (Figure 2). In clubs, there were a median of 12 (IQR, 6–16) medical and 9 (IQR, 6–15) performance staff members. In the case of national federations, the median numbers were 10 (IQR, 6–15) and 6 (IQR, 3–24) respectively. The number of medical and performance staff members by employment type and player age category (team) distribution are summarized in Supplementary Tables 1, 2. Organizational structures were in

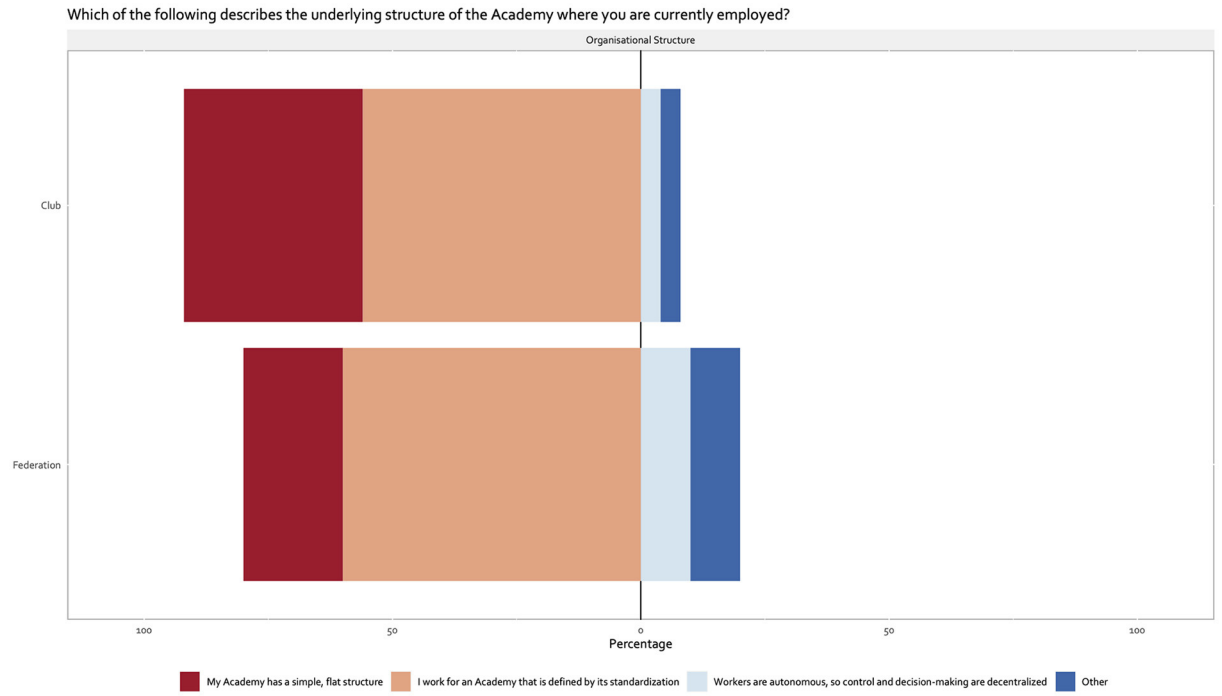


FIGURE 2
Organizational structure.

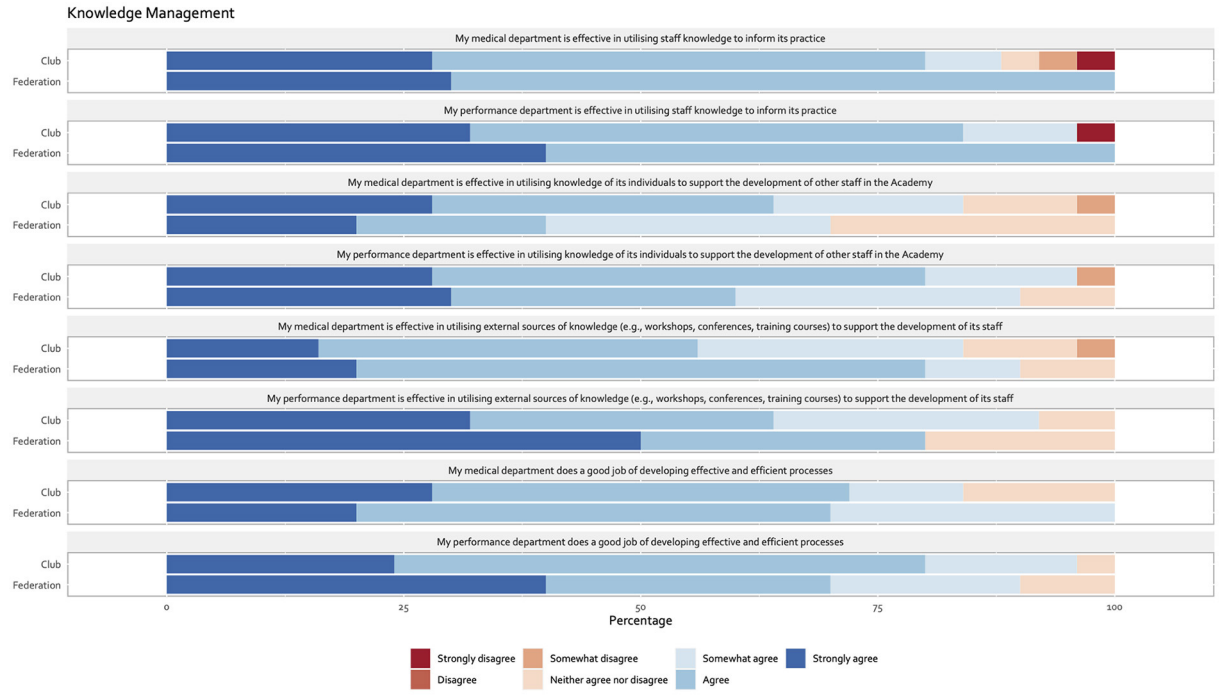


FIGURE 3
Knowledge management.

place for 5 years (IQR, 2–8 years) and 8 years (IQR, 5–12) and reviewed on yearly basis in the majority of clubs and national federations, respectively.

## Knowledge management

Results were summarized and illustrated in Figure 1. The majority of respondents agreed their medical and performance departments were effective in utilizing staff knowledge to inform practice at their clubs and national federations, respectively (Figure 3). The majority of respondents also agreed that their medical and performance departments were effective in utilizing the knowledge of its staff and external sources of knowledge to support the development of other staff in the Academy (Figure 3). However, in national federations, less than half of respondents agreed their medical department was effective in utilizing knowledge of its staff to support the development of other staff in the Academy (Figure 1). The majority of respondents agreed their medical and performance departments were effective in developing efficient processes within their clubs and national federations (Figure 3).

## Return-to-play phases

The proportion of club and national federation staff members involved in the different stages of return-to-play is illustrated in Supplementary Table 3. During the return-to-training phase, 40%−60% of club and national federation respondents perceived the medical area as extremely influential. Approximately a third (30%−36%) of these respondents perceived the performance area as very influential. The role of medical doctors and physiotherapists was perceived as extremely influential and very influential by approximately a half of club (48%−56%) and a third of national federation (40%) respondents. A third of respondents (30%−32%) perceived dedicated return-to-play specialists as very influential in this phase. Perceptions on the influence of massage therapists, team fitness coaches, gym fitness coaches, and sports scientists were unclear (no consensus amongst the distribution of responses).

For the return-to-competition phase, approximately half of club and national federation respondents perceived medical and performance areas as very influential (40%−48%). Team fitness coaches and physiotherapists were perceived as very influential by approximately a third-to-half of club (40%−44%) and national federation (30%−50%) respondents. The role of doctors in this phase was perceived as very influential and extremely influential by club (44%) and national federation (40%) respondents, respectively. Unclear perceptions emerged regarding the influence of massage therapists, gym fitness coaches, and sports scientists during the return-to-competition phase.

For the return-to-performance phase, the majority of club and national federation respondents perceived the performance area as extremely influential (∼60%). In contrast, perceptions regarding the role of the medical area were unclear. Team fitness coaches were perceived as extremely influential by approximately half of respondents (40%−48%). The role of doctors in this phase was perceived as somewhat influential and extremely influential by approximately a third of club and national federation respondents (30%−40%), respectively. A minority respondents perceived sports scientists as somewhat influential and extremely influential at their clubs (24%) and national federations (30%), respectively. The influence of other staff members in this phase was unclear. The majority to almost all of the respondents indicated that consensus among staff members is generally sought to inform the return-to-play process (60%−96%), outcomes from layoffs longer than 28 days are formally reviewed (70%−88%) and recorded to guide future practice (60%−88%) by medical and performance staff. Outcomes of this process are shared with performance team, coaches, and academy director in the majority of clubs (72%−88%).

## Injury prevention

Team fitness coaches were perceived as extremely influential in the injury prevention process by approximately a third-to-half of the club (44%) and national federation (40%) respondents. Likewise, approximately a third of club (32%) and national federation (30%) respondents perceived physiotherapists as very and extremely influential in the injury prevention process. A minority to approximately a third perceived gym and dedicated fitness coaches as very influential in the process within club and national federations, respectively. The role of doctors and massage therapists was perceived as not at all or slightly influential in the prevention process irrespective of the organization context.

The majority to almost all of the respondents indicated that decision making during the injury prevention process is informed by consensus among staff members (80%−90%), the injury prevention process is formally reviewed (60%−72%) and recorded to guide future practice (60%−92%) by medical and performance staff. Approximately half of the respondents (40%−48%) indicated that injury data are reviewed on a weekly basis. A majority of club respondents (68% to 88%) indicated outcomes of this process are generally shared with performance team, coaches, and academy director. Approximately half of national federation respondents (40%−50%) indicated injury prevention outcomes are shared with performance team and coaches. Club and national federations respondents indicated knowledge of (clinical) injury history, training/match load management, and strength training as the three most important factors informing injury prevention strategies.

Likewise, respondents indicated staff communication, fixture congestion, and time constraints as the three main challenges faced by medical and performance staff for preventing re-injury.

Club respondents indicated the median number of weekly prevention sessions during pre-training, warm-up, in-training, and post-training was 4 (IQR, 2–5), 5 (2–5), 2 (0–3), and 3 (2–4), respectively. The typical length of each these sessions was 15 min. In national federations, the median number of prevention sessions included in a typical week was 3 (2–5) pre-training, 4 (2–6) during warm-up, 3 (2–5) in-session, and 5 (4–6) post-training. A session during each of these phases typically ranged from 10 min (i.e., post-training) to 25 min (i.e., pre-training). Injury prevention programmes are typically delivered both pre- and post-training both at group and individual player level in the majority of clubs (60%—80%). The majority of the respondents also indicated that programmes are included also in group-level warm-up sessions (68%). Approximately half to the majority of national federations include group-level prevention programmes during pre-training and warm-up (50%—60%).

## Data management

Respondents indicated that medical and performance data were generally centralized across the first team and at academy level in approximately half and the majority of clubs and national federations, respectively (range, 50%—72%). Almost all of the clubs and national federations use a data management system (range, 70%—92%), with an off the shelf solution provided by an external company accounting for approximately a third of responses. Medical and performance data are integrated within the same data management system in the majority of clubs (68%), yet only in approximately a third-to-half of national federations (40%). From a medical perspective, measures of external load (i.e., running distances), physical performance assessments, and subjective measures of perceived effort data were the three most important sources of performance data informing medical decision-making processes. From a performance perspective, injury audits, staff communication, and injury history were the three most important sources of medical data informing the performance-related decision-making process.

## Research and development

Activities inherent to research and development were reported for the majority and approximately half clubs and national federations (range, 50%—72%). Irrespective of the context, club and national federation respondents indicated research and development activities to be led, in general, by the head of performance (38%) and team doctor (21%) with no specific research-training at academic level (i.e., PhD degree). The majority of clubs undertake research internally *via* club staff (∼100%), and academic collaborations (50%—88%), whereas external consultants and industry partnerships with companies accounted for approximately half of responses. Research and development at national federations generally takes place internally *via* internal staff. Approximately half of national federation respondents indicated external consultants guide research and development processes, with academic collaborations and industrial partnerships accounting for only a minority of responses.

Approximately a third of club respondents indicated ideas suggested by full-time staff members, strategic departmental decisions, and the presence of specific staff members responsible for research and development as very important to identify areas of research and development, with unclear perceptions on the role of external consultants to inform this process. The perceptions of national federation respondents regarding factors relevant to research and development activities at their organizations were unclear, with approximately a third identifying strategic departmental decisions as very important to this process. Presentations and workshops represented approaches adopted to disseminate knowledge developed from research and development activities in the majority and approximately a third-to-half of clubs and national team federations.

# Discussion

The present study explored and discussed general perspectives of practitioners regarding the operational structure and practices of medical and performance units in elite youth football academies from around the world. This survey addresses the dearth of previous research on operational processes central to the functioning of elite academy medical and performance departments. Importantly, our findings provide a general basis for researchers and partitioners to work toward optimizing the functioning of these important areas in elite youth academies.

## Strategy and structure

An organization's structure and operational systems are closely linked to its strategy and the two are deeply intertwined (4, 5). Organizations generally accept that strategic assets include elements such as operational efficiency and knowledge management (4, 5). While previous research explored the general strategy, structure, and operational systems of elite football clubs in European countries (2), our study provided a more contemporary characterization regarding the nature and implementation of processes within medical and performance departments operating in clubs and national federations from

around the world. In the majority of clubs and federations taking part in our investigation, the first team and academy medical and performance operations were strategically aligned, with medical staff overseeing academy medical operations reporting to those overseeing the first team (range, 60%−90%). Similarly, almost all clubs and federations indicated that medical and performance strategies were aligned. In practical terms, this suggests a relatively high degree of integration between senior and academy units as well as medical and performance units within the Academy. An integrated approach has been advocated in other sports in an attempt to move away from delivery models based on reductionist multi-specialist systems, where ineffective decision-making arises through a lack of integration and effective communication (11). In elite football, the benefits of an integrated approach appear supported by investigations suggesting teams with high internal communication quality within the medical team and between the medical and performance team experience lower injury rates and high player availability compared to teams with low communication quality (19). Notably, only 40% of club and 50% of federations had the same individual leading both medical and performance areas, however, we were not currently able to ascertain the underlying rationale for adopting such structures and the relative strengths and weaknesses of each approach.

The scrutiny of the structure underlying club and federation academies from our sample followed principles and notions inherent to the organizational structure frameworks described by Steiger et al. (4) and Mintzberg (15). The majority (∼60%) of club and national federation respondents indicated their academies' organization "is defined by its standardization. Work is very formalized, there are many routines and procedures, decision-making is centralized, and tasks are grouped by professional departments. Our roles are clearly defined. We have a formal planning process with budgets and audits, (internal or external) and procedures are regularly appraised for efficiency". These characteristics align with the organizational type described as "strategic business unit" where formalization is important including the development of procedures for many important operating processes (3, 16, 20). Strategy is typically a top-down function with decision-making, strategic planning and work process managed at the top of the organization (4, 15). The remaining club and federation academies respondents largely indicated their academies' organization "has a simple, flat structure consisting of one large unit with one or a few top managers. The Academy is relatively unstructured and informal compared with other types of organizations, and the lack of standardized systems allows the Academy to be flexible and make decisions quickly". Such organizations are described as functional with greater emphasis placed on the professional skills of the employees alongside increased autonomy (4, 15, 20). The presence of two largely dominant structures supports observations suggesting that, within and between countries, formal structures of modern football organizations are becoming increasingly homogenized (2). This likely represents, to some extent, measures implemented by some key stakeholders (e.g., UEFA) and national football association (2). For example, the more formalized structure of academies in England (21) and an increasing number of European countries (e.g., France and Italy) is likely attributed to the need to align with regulations established by the league governance as part of a centralized funding model to support youth player development. Whilst the benefits and challenges of the two structures presently observed were discussed in the context of other industries (4, 15), understanding how such structures might optimize real-world solutions in the context of the key performance indicators common to the modern football academy could warrant further investigation. Likewise, given the global reach of the current survey, more in-depth research might shed more light on the factors responsible for the dominant structures currently in place at modern football organizations (e.g., governance, strategic, cultural, financial etc).

Within the overall academy structure, part-time contractual staff typically out-numbered full-time staff in both club and federation academies, lending support to previous observations on the overall structure of elite global academies (2). The substantial heterogeneity in the composition and number of medical and performance professionals employed in the present teams aligns with previous findings in a survey of 78 European professional teams (22). Doctors and physiotherapists were present in all club and federation academies, yet the number employed varied especially those on part-time contracts. The variation in the number of massage therapists, sport scientists and pitch-based fitness conditioning staff (team level) was also evident with no part-time or full-time individual employed in these capacities in some academies. Similarly, no part-time or full-time osteopath/chiropractor or psychologist were employed in some club and federation academies. All academies employed at least one part-time dedicated nutritionist within the medical or performance team and one dedicated return to play specialist. A number of factors are likely to explain this diversity in the composition of medical and performance expertise. As previously noted, measures implemented by some national football associations and leagues play an important role in some countries (2). For example, youth development regulations in the English Premier League (21) and Italian Football Federation (23) means it is mandatory for clubs to incorporate specific expertise in accordance with its academy category. In France, the French Football Federation's regional academies are required to include a full-time performance analyst and strength and conditioning coach within their structure. In these countries, external financial support is often provided to the clubs to facilitate the introduction of more specialized staff. In other countries (e.g., Qatar), the national football association and league offer financial support to the clubs along with centralized support encompassing medical and performance expertise. The relative importance of youth development to each club's business

model together with the club's own financial resources will also influence the scale and composition of staff employed within the same country and between countries (2). Since a high proportion of clubs and federations indicated the first team and academy medical and performance operations were strategically aligned, it is likely, in some instances, that specialist staff from the first team environment were also providing some support to the Academy where such resource was not available. Aside from any financial benefit, importantly, such integration is only likely to be advantageous in facilitating effective communication across the clubs medical and performance team (11). Different working practices within and between countries due to different practitioners' responsibility, skill base and the specific culture associated with a particular environment are also likely to have influenced the scale and composition of staff available (2).

## Knowledge management

As organizations strive to enhance their competitive advantage in today's knowledge-based economy, knowledge management has become an increasingly important strategic asset for organizational success (4, 24–26). Knowledge transfer is a key component of knowledge management and is concerned with promoting and facilitating knowledge sharing, collaboration, and networking for better decision-making (4, 6, 26, 27). Our study examined four components of knowledge transfer within the context of academy medical and performance setting. The majority of respondents highlighted their medical and performance department was effective in utilizing staff knowledge to inform its practice, utilizing the knowledge of its own staff and external sources of knowledge to support the development of other staff and developing effective and efficient processes for transferring knowledge. Business strategy and organizational structure represent important success factors mediating knowledge management (24). The relatively high degree of integration between senior and academy departments as well as Academy medical and performance departments, together with their largely formalized structures, is therefore likely to have served to some extent to facilitate knowledge transfer within the Academy setting. Interestingly, less than half of respondents in federations agreed their medical department was effective in utilizing knowledge of its staff to support the development of other staff. Since no apparent differences in organizational structures and systems were currently identified between club and federations, further work may be relevant to elucidate the reasons for such differences. Additionally, organizational culture, leadership and technology represent important elements of knowledge strategies for successful knowledge management implementation (6, 28, 29). It is, therefore, likely that several factors beyond the reach of the current study contribute to the reported limitations in knowledge transfer currently observed.

## Return-to-play phases

Return-to-sport (play) decision-making in sport is complex and challenging since it is linked to the athlete's wellbeing and performance (30). A number of frameworks have been developed to facilitate decision-making during return-to-sport (16, 31, 32). The notion that shared decision-making amongst the various disciplines, coach and athlete is likely to improve outcomes and satisfaction with the process by eliminating the contextual "blind spots," such as an individual's expectation, preference, and value is common to the different framework's researchers proposed to date (11, 30, 31). Accordingly, our study sought to derive insights into decision-making across key stages of the return-to-sport continuum: return to participation (training), return to sport (competition) and return to performance (16). Shared decision-making was common practice with the majority to almost all respondents indicating that decision-making was informed by consensus amongst all medical and performance practitioners involved in the process. Outcomes from layoffs >28 days were formally and collectively reviewed by the medical and performance team, recorded to guide future practice, and shared across with the wider performance team, coaches, and academy director. Alongside shared-decision-making, the present findings also document, for the first time, the relative influence of medical and performance units together with specific roles within each unit are dependent on the stage of the return-to-play continuum. Doctors and physiotherapists were perceived to be very influential to extremely influential during return-to-training and return-to-competition phases, respectively, while the majority of respondents perceived the performance area as extremely influential during return to performance. A dedicated return-to-play specialist was perceived as very influential during return to training while team fitness coaches were seen as very influential during return-to-competition and return-to-performance phases. Sports scientists were also extremely influential during the return-to-performance phase.

## Injury prevention

Injury prevention in the real-world is complex due to the diversity of contextual factors which influence the implementation of injury prevention programmes (33, 34). Research directed toward understanding contextual factors which influence the delivery of injury prevention strategies in professional football academies is limited (35, 36). We sought to derive insights into the delivery, content and implementation challenges of injury prevention strategies in elite academies. Individuals delivering injury prevention programmes play a key role in achieving the desired outcomes (36, 37). Approximately 40% of clubs and federations indicated that team fitness coaches were very influential in the injury prevention process while

approximately a third of respondents perceived physiotherapists as very and extremely influential. In some instances, up to a third of respondents also highlighted that gym and dedicated fitness coaches were very influential in the process. Fitness coaches have also previously been identified as the primary deliverers of injury prevention programmes in a small sample of professional academies (36). Consistent with this, the position of the physiotherapist was the most represented position in the injury prevention programme in a survey of professional teams (38). In this context, doctors were perceived as not at all or only slightly influential in the prevention process irrespective of the organization context in contrast to perspectives concerning their importance in the return-to-play process. This may infer input from doctors is mainly strategic in nature with development and delivery of the programme undertaken mainly by other experts in the support team. Indeed, doctors have previously been shown to be mainly involved in the design and assessment aspects of injury prevention programmes with little input into the delivery phase (38).

A range of injury prevention facilitators and barriers have previously been observed in professional football settings (35–39). In line with such observations, club and national federations respondents indicated injury history, training load management, and strength training as three important factors informing injury prevention strategies (39). The majority (60%—90%) of respondents currently reported that decision-making was sought through consensus amongst those staff involved in the injury prevention process. Majority of club respondents and half of national federations also reported outcomes of the process are generally shared with performance team and coaches with clubs also sharing outcomes with the academy director. These insights align closely with observations in professional youth soccer from a delivery and support perspective where programme implementation facilitators included acceptance/support from the head coach and other staff, yet lack of communication and teamwork emerged as important barriers (35, 36). In fact, staff communication was currently rated as one of three main challenges faced by medical and performance staff for preventing re-injury. A lack of planning is also seen as a barrier to successful programme implementation (35, 36). In line with such observations, the majority of club and federation respondents reported that the injury prevention strategy is formally reviewed, recorded to guide future practice by medical and performance staff with nearly half of the respondents indicating that injury data are reviewed on a weekly basis. Club and federation respondents also rated fixture congestion and associated time constraint as two of the three main challenges faced by medical and performance staff for preventing re-injury. Similar club and governing body related barriers have been documented in other youth professional football settings (35, 36).

Programme structure and practicality from a delivery perspective also constitute important facilitators/barriers for programme implementation (35, 36). The median number of injury prevention sessions delivered on a weekly basis by clubs and federations was ∼15. In clubs, the majority of sessions were delivered pre-training and during the warm-up period while federations tended to deliver more sessions before and after training. Sessions were typically done as part of a group though the majority of clubs also included programmes at the individual player level. The number of weekly sessions is far higher than previously observed in elite senior professional players with players typically undertaking 2–5 sessions per week during the pre-season and in-season periods (38). Such differences probably reflect the increased time constraints placed upon senior players due to the demands of competition. With less competition demands, especially during the mid-part of the week, there is far more opportunity to allocate time to player development within the youth setting.

## Data management

The ongoing evolution of the football industry in recent years resulted in modern organizations broadening the number of support staff and their internal domain expertise (40). The progressive metamorphosis of football organizations into structured corporates dedicated to optimal player management reflected the impact of embedding sports sciences in pursuing an evidence-based approach *via* the integration of best practice and experience informed by academic research findings (40). In practical terms, this contributed to re-shaping routine processes of contemporary football organizations now recruiting professionals with backgrounds in physiology, strength and conditioning, biomechanics, and performance analysis (40). Nevertheless, the need to develop systematic analysis frameworks to enhance performance within their organizations is a recent phenomenon that received particular consideration. Accordingly, the business-related nature of modern football organizations now demands establishing flexible data analytics solutions to leverage processes for strategic advantage and remain competitive on both a sport and financial levels (41). Starting with a formal understanding of the business strategy (41), integrating all these cyclical elements is necessary to generate more nuanced sources of information that may be deployed into applied business solutions. From an operational standpoint, establishing formal athlete management systems now constitutes the first step for football organizations to turn data into knowledge that can streamline decision-making processes at corporate and practitioner levels (40).

Our findings revealed an appreciation among football organizations for the centralization of information, with this practice more common at a club than national federation level. Conversely, club and national federation respondents indicating an off the shelf solution provided by an external company highlighted a general lack of expertise in deploying information

technology solutions and data analysis at their organizations. Such a finding is consistent with the fact that embedding information technology and data analytics expertise into the support staff remains at an embryonic stage, thereby limiting the promotion of decision support services integrating elements of data collection, analysis, and communication at present (40). To advance current service provision processes and cope with the demands of a self-evolving industry, our investigation further highlighted the need for modern football organizations to ensure their support teams are equipped with information technology, biostatistics, and epidemiology expertise (42).

## Research and development

In today's knowledge economy, football organizations must innovate in order to remain competitive in their industry. Innovation *via* applied research is commonly undertaken within professional team sports in attempt to positively impact performance when translated into practice (43, 44). Building on previous observations on collaborative sport science research in professional team sports (44), we sought to better understand the research philosophies of the club academies and national federations. In line with these observations, research activities were reported for the majority of clubs and approximately half the national federations. Overall leadership of research activity was undertaken by senior performance or medical staff within the club or federation despite no specific research-training at academic level (i.e., PhD degree). Whilst research leadership has typically been driven by the academic partner where teams engage in research collaboration with universities, the role of the practitioner is typically more evident in driving the strategic direction of the research vs. the more technical elements of the research (44). Unless sufficiently equipped with research skills, in the current context, it is likely the nature of the role of senior performance and medical staff is more strategic in nature from the perspective of the club or federation. In line with this observation, approximately a third of club respondents indicated that the departmental strategy together with ideas suggested by full-time staff members and the presence of specific staff members (full-time employed) responsible for overseeing research and development as very important to identify areas of research and development. Strategic departmental decisions were also deemed very important to the research process by a third of all federations. This suggests the core internal staff play a key role in driving the research strategy of clubs and federations. Indeed, the role of external consultants in informing the research direction of clubs and federations was unclear.

Alongside leadership and ideation, the majority of clubs and federations indicated that internal staff also play an important role in research delivery. While this research activity is likely to revolve around the less technical aspects of research *per se* (44), their importance may also partly reflect in some cases the growing number of research-active practitioners undertaking research-based continuous professional development (e.g., PhD and professional doctorate programmes) alongside their day-to-day roles in the organization (26, 44). This development effectively enables them to operate as an embedded scientist within the organization therefore increasing its internal research capability (26, 44). As in other industries, collaborative partnerships with external entities such as universities and private entities have also become increasingly popular vehicles through which sports organizations can harness the required knowledge and expertise to drive research activity (26, 43–45). Individual external consultants (e.g., University academics) accounted for half of responses in both clubs and federations. Despite the majority of clubs also engaging in more formal University research collaboration (e.g., PhD student) and industrial partnerships with companies, only a small number of federations engaged in such activities. Any consideration regarding the contribution of the factors explaining such differences cannot be discerned from the present investigation. Nevertheless, it would be plausible to assume that increased access affords greater opportunity to undertake more extensive research programmes since players spend the majority of their time in the club environment.

# Conclusion

The present survey of elite youth professional football academies from around the world provides new insights regarding key operational processes delivered by medical and performance practitioners. The organizational structure of the majority of academies was very formalized and standardized. Strategy was typically a top-down function with decision-making, strategic planning, and operating processes managed at the top of the organization. Academy medical and performance units were strategically aligned as well as closely integrated with their respective first team units. Survey responses indicated the composition and number of medical and performance professionals employed in academies were both heterogenous. Medical and performance units were largely effective in utilizing staff knowledge to inform its practice, utilizing the knowledge of its own staff and external sources of knowledge to support the development of other staff and developing effective and efficient processes for transferring knowledge. During injury prevention and return-to-play processes, shared decision-making was common practice. The relative importance of specific practitioner's during both injury prevention and return-to-play processes was highlighted by the academies. Medical and performance data were integrated within the same data management system in clubs but to a lesser degree in federations. Research and development activity were reported for most academies and typically led by the head of

performance or team doctor. The majority of academies conduct research internally *via* club staff, academic collaborations and/or external consultants and industry partnerships. Information regarding practices and perceptions of professional clubs in the aforementioned area will be of interest to those in the football industry. Collectively, the present study provides a contemporary overview which can inform both current practice and future research in football academy medical and performance departments.

## 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 Aspire Zone Foundation Institutional Review Board, Doha, State of Qatar (protocol number: E202007005). The patients/participants provided their written informed consent to participate in this study.

## Author contributions

WG, CC, AG, JO'B, PR, FT, DB, EL, JM, LL, and VS provided substantial contributions to the conception and design of the work and interpretation of the findings. LL conducted the data analysis. WG and LL wrote the manuscript. All authors read and approved the submitted version.

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## Conflict of interest

Authors WG, DB, EL, LL, and VS were employed by the company Aspire Academy. Author AG was employed by the company Juventus FC. Author JO'B was employed by the company Red Bull Athlete Performance Center. Author PR was employed by the company Premier League. Author FT was employed by the company Sporting Clube de Portugal.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2022.1031721/full#supplementary-material

## References

1. Slack T, Parent M. *Understanding Sport Organizations: The Application of Organization Theory*, 2nd ed. Champaign, IL: Human Kinetics (2006).

2. Relvas H, Littlewood M, Nesti M, Gilbourne D, Richardson D. Organizational structures and working practices in elite European professional football clubs: understanding the relationship between youth and professional domains. *Eur Sport Manag Q.* (2010) 10:165–87. doi: 10.1080/16184740903559891

3. De Knop P, Van Hoecke J, De Bosscher V. Quality management in sports clubs. *Sport Manage Rev.* (2004) 7:57–77. doi: 10.1016/S1441-3523(04)70045-5

4. Steiger JS, Hammou KA, Galib MH. An Examination of the influence of organizational structure types and management levels on knowledge management practices in organizations. *Int J Bus Manag.* (2014) 9:1–15. doi: 10.5539/ijbm.v9n6p43

5. Grant RM. *Contemporary Strategy Analysis*. Hoboken, NJ: Wiley and Sons, Inc. (2019).

6. Ranaweera J, Weaving D, Zanin M, Roe G. Identifying the current state and improvement opportunities in the information flows necessary to manage professional athletes: a case study in rugby union. *Front Sports Act Living.* (2022) 4:882516. doi: 10.3389/fspor.2022.882516

7. Ford PR, Bordonau JLD, Bonanno D, Tavares J, Groenendijk C, Fink C, et al. A survey of talent identification and development processes in the youth academies of professional soccer clubs from around the world. *J Sports Sci.* (2020) 38:1269–78. doi: 10.1080/02640414.2020.1752440

8. Ryan D, Lewin C, Forsythe S, McCall A. Developing world-class soccer players: an example of the academy physical development program from an English Premier League team. *Strength Cond J.* (2017) 40:2–11. doi: 10.1519/SSC.0000000000000340

9. Bergeron MF, Mountjoy M, Armstrong N, Chia M, Côté J, Emery CA, et al. International Olympic Committee consensus statement

on youth athletic development. *Br J Sports Med.* (2015) 49:843–51. doi: 10.1136/bjsports-2015-094962

10. Ford P, Croix MDS, Lloyd R, Meyers R, Moosavi M, Oliver J, et al. The long-term athlete development model: physiological evidence and application. *J Sports Sci.* (2011) 29:389–402. doi: 10.1080/02640414.2010.536849

11. Dijkstra HP, Pollock N, Chakraverty R, Alonso JM. Managing the health of the elite athlete: a new integrated performance health management and coaching model. *Br J Sports Med.* (2014) 48:523–31. doi: 10.1136/bjsports-2013-093222

12. Ekstrand J, Krutsch W, Spreco A, Zoest W, van Roberts C, Meyer T. Time before return to play for the most common injuries in professional football: a 16-year follow-up of the UEFA Elite Club Injury Study. *Br J Sports Med.* (2020) 54:421. doi: 10.1136/bjsports-2019-100666

13. McCall A, Pruna R, Van der Horst N, Dupont G, Buchheit M, Coutts AJ, et al. Exercise-based strategies to prevent muscle injury in elite footballers: a systematic review and best evidence synthesis. *Sports Med.* (2020) 50:1667–81. doi: 10.1007/s40279-020-01315-7

14. McCall A, Dupont G, Ekstrand J. Injury prevention strategies, coach compliance and player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical officers. *Br J Sports Med.* (2016) 50:725. doi: 10.1136/bjsports-2015-095259

15. Mintzberg H. *Structures in Five: Designing Effective Organizations*. Englewood Cliffs, NJ: Prentice-Hall Inc. (1983).

16. Ardern CL, Glasgow P, Schneiders A, Witvrouw E, Clarsen B, Cools A, et al. Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med.* (2016) 50:853. doi: 10.1136/bjsports-2016-096278

17. Amrhein V, Trafimow D, Greenland S. Inferential statistics as descriptive statistics: there is no replication crisis if we don't expect replication. *Am Stat.* (2019) 73:262–70. doi: 10.1080/00031305.2018.1543137

18. Agresti A, Coull BA. Approximate is better than "exact" for interval estimation of binomial proportions. *Am Stat.* (1998) 52:119–26. doi: 10.1080/00031305.1998.10480550

19. Ekstrand J, Lundqvist D, Davison M, D'Hooghe M, Pensgaard AM. Communication quality between the medical team and the head coach/manager is associated with injury burden and player availability in elite football clubs. *Br J Sports Med.* (2019) 53:304–8. doi: 10.1136/bjsports-2018-099411

20. Martínez-León IM, Martínez-García JA. The influence of organizational structure on organizational learning. *Int J Manpower.* (2011) 32:537–66. doi: 10.1108/01437721111158198

21. Premier League. (2022). Available online at: https://www.premierleague.com/youth/EPPP (accessed July 1, 2022).

22. Droste JN, Fisser S, Gebhardt M, Edler C, Lippie E, McAleer S. Mitarbeiter im professionellen europäischen Fußball – Vergleich der Personalstruktur in der Sportmedizin, -wissenschaft und Physiotherapie zwischen der Bundesliga, La Liga, Serie A und der Premier League. *Sportverletzung · Sportschaden.* (2021) 35:147–53. doi: 10.1055/a-1386-6932

23. Italian Football Federation. (2022). Available online at: https://www.figc.it/it/federazione/norme/regolamento-del-settore-tecnico/ (accessed July 1, 2022).

24. Chong CW, Chong SC. Knowledge management process effectiveness: measurement of preliminary knowledge management implementation. *Knowl Manag Res Pract.* (2009) 7:142–51. doi: 10.1057/kmrp.2009.5

25. Junco JGD, Zaballa RDR, Perea JGÁ. Evidence-based administration for decision making in the framework of knowledge strategic management. *Learn Organ.* (2010) 17:343–63. doi: 10.1108/09696471011043108

26. Bartlett JD, Drust B. A framework for effective knowledge translation and performance delivery of Sport Scientists in professional sport. *Eur J Sport Sci.* (2021) 21:1579–87. doi: 10.1080/17461391.2020.1842511

27. Chong CW, Chong SC, Gan GC. Inter-organizational knowledge transfer needs among small and medium enterprises. *Libr Rev.* (2011) 60:37–52. doi: 10.1108/00242531111100568

28. Davenport T, Prusak L. *Working Knowledge: How Organizations Manage What they Know*. Boston, MA: Harvard Business School Press (1998).

29. O'Dell C, Grayson J. *If Only We Know What We Know: The Transfer of Internal Knowledge and Best Practice*. New York, NY: Simon and Schuster (1999).

30. Yung KK, Ardern CL, Serpiello FR, Robertson S. A Framework for clinicians to improve the decision-making process in return to sport. *Sports Med Open.* (2022) 8:52. doi: 10.1186/s40798-022-00440-z

31. Creighton DW, Shrier I, Shultz R, Meeuwisse WH, Matheson GO. *Return-to-play in sport: a decision-based model. Clin J Sport Med.* (2010) 20:379–85. doi: 10.1097/JSM.0b013e3181f3c0fe

32. Shrier I. Strategic assessment of risk and risk tolerance (StARRT) framework for return-to-play decision-making. *Br J Sports Med.* (2015) 49:1311–15. doi: 10.1136/bjsports-2014-094569

33. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport.* (2006) 9:3–9. doi: 10.1016/j.jsams.2006.02.009

34. Tee JC, McLaren SJ, Jones B. Sports injury prevention is complex: we need to invest in better processes, not singular solutions. *Sports Med.* (2020) 50:689–702. doi: 10.1007/s40279-019-01232-4

35. O'Brien, J, Finch CF. Injury prevention exercise programmes in professional youth soccer: understanding the perceptions of programme deliverers. *BMJ Open Sport Exerc Med.* (2016) 2:e000075. doi: 10.1136/bmjsem-2015-000075

36. O'Brien J, Young W, Finch CF. The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+. *J Sci Med Sport.* (2017) 20:26–31. doi: 10.1016/j.jsams.2016.05.007

37. O'Brien J, Finch CF. The implementation of musculoskeletalinjury-prevention exercise programmes in team ball sports: asystematic review employing the RE-AIM framework. *Sports Med.* (2014) 44:1305–18. doi: 10.1007/s40279-014-0208-4

38. McCall A, Carling C, Nedelec M, Davison M, Gall FL, Berthoin S, et al. Risk factors, testing and preventative strategies for non-contact injuries in professional football: current perceptions and practices of 44 teams from various premier leagues. *Br J Sports Med.* (2014) 48:1352–7. doi: 10.1136/bjsports-2014-093439

39. Coles PA. An injury prevention pyramid for elite sports teams. *Br J Sports Med.* (2017) 52:1008–10. doi: 10.1136/bjsports-2016-096697

40. Ward P, Windt J, Kempton T. Business intelligence: how sport scientists can support organization decision making in professional sport. *Int J Sports Physiol Perform.* (2019) 14:544–6. doi: 10.1123/ijspp.2018-0903

41. Sreejesh S, Mohapatra S, Anusree MR. *Business Research Process. Business Research Methods: An Applied Orientation*. Cham: Springer International Publishing (2014). doi: 10.1007/978-3-319-00539-3

42. Casals M, Finch CF. Sports biostatistician: a critical member of all sports science and medicine teams for injury prevention. *Inj Prev.* (2017) 23:423. doi: 10.1136/injuryprev-2016-042211

43. Coutts AJ. Challenges in developing evidence-based practice in high-performance sport. *Int J Sports Physiol Perform.* (2017) 12:717–8. doi: 10.1123/IJSPP.2017-0455

44. Malone JJ, Harper LD, Jones B, Perry J, Barnes C, Towlson C. Perspectives of applied collaborative sport science research within professional team sports. *Eur J Sport Sci.* (2018) 19:1–9. doi: 10.1080/17461391.2018.1492632

45. McCall A, Davison M, Carling C, Buckthorpe M, Coutts AJ, Dupont G. Can off-field 'brains' provide a competitive advantage in professional football? *Int J Sports Physiol Perform.* (2016) 50:710–2. doi: 10.1136/bjsports-2015-095807

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# Determining the effect of one decade on fitness of elite Austrian youth soccer players using propensity score matching

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Current trends in attacking strategies and increases in external workload have led to a need for fast and well-conditioned athletes in modern soccer. More recently, progressions in speed, coordination, power and endurance were found over a decade in elite Austrian youth players. However, possible confounders such as relative age, maturation, learning effects, and academy philosophy may have influenced these changes. The present study aimed to determine the decade effect on fitness under statistical control of players' exact age, height, body mass, test location as well as total number of pretests and time interval between test and pretest. Players annually completed a battery of anthropometric, general and soccer-specific fitness tests. MANCOVA was calculated to identify the overall impacts of the covariates on fitness. To balance the covariates of initially 2,530 "former" (2002 to 2005) and 2,611 "recent" (2012 to 2015) players, 1:1 nearest neighbor propensity score (PS) matching was used, resulting in 587 U13, 573 U14, 475 U15, 325 U16, 262 U17, and 129 U18 matched pairs. The decade effect on fitness was assessed by independent *t*-tests and Cohen's *d* separately at each age group. Superior performances of recent players were found for linear sprint across all age categories ($d = 0.154–0.476$) as well as for agility ($d = 0.125–0.340$) and change-of-direction speed ($d = 0.172–0.466$) in U15 to U18. Reaction speed increased in U13 ($d = 0.288$) and U15 ($d = 0.310$). Flexibility reduced over the decade in all age categories ($d = -0.151$ to $-0.589$) and upper-limb power decreased ($d = -0.278$ to $-0.347$) in U13 and U14. Balancing the covariate distribution via PS matching generally confirmed previous findings, with fitness decade effects reflecting the athletic needs for modern soccer. Since fitness performance changed over time, reference values should be periodically updated. Coaches favor both physical and cognitive fast players nowadays. Thus, training should target all aspects of speed, without disregarding flexibility, upper-limb power and other preventive strategies that keep the players on the pitch.

KEYWORDS

football, performance development, nearest neighbor matching, statistical control, conditioning tests, talent

## 1. Introduction

"Transition is the magic moment in a game" (1) and "pace packs a punch" (2) are two observations in recent technical reports from FIFA World Cup 2014 and UEFA EURO 2020. Current successful teams tend to shift their offensive strategies towards "quick attacks

instead of endless elaboration and possession" (3). Referring to English Premier League matches, counterattacks were 3.4 times more effective in creating goal scoring opportunities than combinative play (4). This "vertical mindset" (3) during the transition from defense to offence is characterized by both high ball speed and a low number of passes (5, 6) as well as high sprint speed of the players (7). Associated with this, the goal scoring probability decreases by 7% per additional pass and by 2% per second of attack duration (8). Consequently, modern soccer requires technically and physically skilled players within all playing positions (9).

These trends in attacking strategies are paralleled by greater physical and technical challenges nowadays. Progressions in game speed (i.e., ball speed) and in match structure (i.e., shorter, more intense play periods) (10) as well as increases in external workload (i.e., high-intensity running and sprinting) (11–13) made elite level soccer more physically demanding over the years. In the English Premier League, those increases in workload along with improvements in pitch quality may also have led to more ectomorph players in recent years as they became taller and lighter (14).

Given these trends in body shape and adult match play, it is rational to expect improvements in elite adult and elite youth soccer players' physical fitness over the years. In line with this expectation, sprint performance enhancements have already been found in Norwegian elite adult players (15), and intermittent endurance capacity increased in Dutch U13 to U19 players (16) between the early 90s and late 2000s. On the other hand, power (i.e., countermovement jump) and aerobic capacity (i.e., $VO_{2max}$) of Norwegian elite players (15, 17) as well as height, maturity and functional characteristics (i.e., 10, 20, 40 m sprint, countermovement jump, anaerobic power, $VO_{2max}$, and quadriceps strength) of 13-year-old French academy entrants (18) remained fairly stable during this period. More recently, when comparing elite Austrian youth soccer players' fitness between 2002 to 2005 and 2012 to 2015 seasons, performance increases were found mainly in speed, reaction time, and lower-body power at U13 to U14 age groups as well as in speed, coordination, and endurance at U15 to U18 level (19).

Since these findings in Gonaus et al. (19) were accompanied by changes in anthropometry and birth date distributions and since it is rational to assume that repeated testing and test location biased previous evaluations, it is an important step forward to reanalyze the effect of this 10-year time span (i.e., the effect of the decade) on fitness by best possibly controlling for these confounders. Besides the improvements in fitness, height and body mass increased at younger age groups (i.e., U13 to U14) and a more pronounced relative age effect over the years was present over all age categories, and at U15 level (19). Early born as well as early maturing players may benefit, for example, from temporarily height and weight advantages and superior fitness performance during the talent selection process (20–23), with maturation displaying greater influence on physical performance than relative age (24). In the same vein, even though the criteria for test qualities are fulfilled (25), learning effects resulting from repeated measurements may have influenced the outcome (26). Furthermore, dependent on the academy's philosophy and style of play, different player recruitment criteria and strategies may limit the comparison between players of different academies and talent promotion institutions (27, 28).

To overcome these past limitations, the goal of the current study was to compare the fitness characteristics between former (2002 to 2005) and recent (2012 to 2015) elite Austrian youth soccer players under consideration of the athletes' height, body mass and exact age as well as the total number of pretests, the time interval between pretests and the location of the test. Based on the outlined progression in adult match play and built on our preliminary results, we hypothesized that even under the statistical control of the confounding variables the fitness level in sprint, power and endurance has improved over the investigated decade across age groups (U13 to U18).

## 2. Materials and methods

To test the hypothesis, quasi-longitudinal cohort data from the Austrian soccer talent promotion system were reanalyzed using the propensity score (PS) matching approach to minimize bias in estimation of the decade effect on fitness. The talent promotion system in Austrian soccer was revised in 2001. Since then, U11 to U14 players are selected nationwide and systematically into one of 29 accredited youth development centers (YDC) and the most talented youngsters are subsequently drafted into one of 12 (until 2008: 13) youth soccer academies, covering age groups U15 to U18 (19). In the present analysis, all YDC players at age groups U13 to U14, and all U15 to U18 youth academy players of the seasons 2002 to 2005 and, one decade later, of the seasons 2012 to 2015 were included. These players belong to the highest performance level in their age category in Austria. To monitor the athletic progression during adolescence, all promoted players have to perform a battery of anthropometric, general and soccer-specific fitness tests once, in autumn (U13 to U14), or twice, in summer and winter (U15 to U18), a year. These data were collected within a collaborative project of the Austrian Football Association [Österreichischer Fußball-Bund (ÖFB)], the Department of Sport and Exercise Science of the University of Salzburg and the Elite Sport Centre Austria [Leistungssport Austria; former Institute for Sports Medicine and Science Austria] with the aim to scientifically guide the education and training monitoring in elite Austrian youth soccer players between the ages of 12 to 18 years. When entering the promotion system, all players and their parents or guardians sign a training agreement with the ÖFB, who, for their part, gave their permission to the scientific processing of the data. The study conformed to the Declaration of Helsinki and ethical approval was obtained from the local university ethics committee. Parts of the dataset have been used in two previous studies of Gonaus and Müller (29), and Gonaus et al. (19).

### 2.1. Procedures

To ensure objectivity and standardization, the tests were exclusively conducted by experienced performance diagnosticians

and students from either the Department of Sport and Exercise Science of the University of Salzburg, or the Elite Sport Centre Austria on an indoor surface. The time of the day, the sequence of the tests, starting with non-fatiguing exercises, and the measurement systems (30–32) were kept identical throughout the years.

After providing instructions about the test protocol and execution, players' *exact age*, *height* (measured with SECA 217 stadiometer, SECA, Hamburg, Germany), and *body mass* (measured with SECA 813 flat scale, SECA, Hamburg, Germany) were recorded. Following this, the players engaged in a 15 min standardized warm-up, which included running exercises, mobility and activation exercises, as well as sprints. All players consecutively started with one trial of *20 m sprint* and *foot tapping*, subsequently performed two attempts of *sit-and-reach* and *2 kg standing medicine ball throw*, and continued with the second trials of *20 m sprint* and *foot tapping*. Afterwards, they each performed one attempt of *reaction test*, and two trials of 5 × 10 m shuttle sprint, *hurdles agility run*, *countermovement jump* and *drop jump* in a random order. Following a break of 30–45 min, U15 to U18 players conducted the *20 m multi-stage endurance run*. For those tests permitting two attempts, sufficient time to recover was scheduled and only the better score remained for statistical purposes.

## 2.2. Fitness test battery and measurement systems

*5, 10, 20 m sprint*: Linear sprint speed was assessed by *20 m sprint* with 5 and 10 m split times (to the nearest 0.01 s; ICC = 0.561–0.837, Cronbach's Alpha $\alpha = 0.762–0.937$).

*5 × 10 m shuttle sprint*: Change-of-direction speed was determined by 5 × 10 m shuttle sprint with each 180° turns (0.01 s; ICC = 0.846, $\alpha = 0.923$).

*Hurdles agility run*: General agility was quantified using the *hurdles agility run* (0.01 s; ICC = 0.793, $\alpha = 0.893$). A schematic representation of the test setup and the procedure can be found in Gonaus and Müller (29).

Infrared timing gates (Brower Timing Systems, Utah, United States) placed 90 cm above ground were used in all sprint tests and in the agility task. The players started in a step position 0.5 m behind the first timing gate.

*Reaction test*: Lower-limb multi-choice reaction speed was determined by an eye-foot coordination task determining the mean reaction time of 20 stimuli (1 ms; ICC = 0.476, $\alpha = 0.698$) within four possible directions via the computer-based system of Fitronic (Fitronic Inc., Bratislava, Slovakia).

*Foot tapping*: Maximal speed of lower limbs was assessed using *foot tapping* over 5 s and subsequently calculating bipedal cycles per second (0.1 Hz; ICC = 0.925, $\alpha = 0.965$).

*20 m multi-stage endurance run*: Aerobic endurance performance was evaluated by the speed corresponding to 4 $mmol \cdot l^{-1}$ (0.1 $km \cdot h^{-1}$; ICC = 0.805, $\alpha = 0.916$), determined by repetitive 20 m runs for 3 min at 7.92, 9.72, 11.52 and 13.32 $km \cdot h^{-1}$, and blood lactate sampling during 90 s break intervals in between (Lactate Analyzer Biosen 5040, EKF Industrie-Elektronik, Barleben, Germany).

*Countermovement jump*: Lower-body power was evaluated using vertical *countermovement jump* with arm swing (0.1 cm; ICC = 0.749, $\alpha = 0.863$).

*Drop jump*: Lower-body reactive strength was assessed using two-legged *drop jump* (coefficient 0.01; ICC = 0.744, $\alpha = 0.860$). The performance from 30 cm (U13 to U14) and 40 cm (U15 to U18) drop height was operationalized by the formula described in Gonaus and Müller (29), taking jump height (0.1 cm) and ground contact time (1 ms) into account.

Both jump tests and the foot tappings were recorded without shoes using a Kistler force plate (Kistler Instrument Corporation, Winterthur, Switzerland).

*2 kg medicine ball throw*: Upper-limb power was determined by an overhead ball throw using a 2 kg medicine ball in size 4 of a football and with a maximum of one-step run-up (0.1 m; ICC = 0.935, $\alpha = 0.967$).

*Sit-and-reach*: The performance in general flexibility was assessed by the *sit-and-reach* (1 cm; ICC = 0.964, $\alpha = 0.990$). Positive values indicating that the players reached over their toes while standing on a sit-and-reach box.

A more detailed description of all single tests as well as the reliability analyses of a comparable sample of academy players are provided by Gonaus and Müller (25, 29). According to the principle component analysis in Gonaus and Müller (29), the tests were categorized into "speed" (*5, 10, 20 m sprint*, and *shuttle sprint*), "coordination and endurance" (*agility run*, *reaction test*, *foot tapping*, and *endurance run*), and "power and flexibility" (*countermovement jump*, *drop jump*, *medicine ball throw*, and *sit-and-reach*).

## 2.3. Participants

Analogous to Gonaus et al. (19), the data of 2,530 "former" players tested in the years from 2002 to 2005, and of 2,611 "recent" players tested from 2012 to 2015 were considered. Only the test results from autumn (i.e., September or October; U13 to U14) and winter (i.e., November, December or January; U15 to U18) were regarded. Some players were repeatedly tested during the respective 4-year period, whereas others, due to normal fluctuation within the promotion program, injuries or any other reason for nonparticipation, were investigated less often, leading to a total of 4,058 (2002 to 2005) and 4,448 (2012 to 2015) measurements. Only complete datasets including all anthropometric characteristics and at least 8 out of 9 fitness tests (U13 to U14) or 9 out of 10 tests (U15 to U18) were analyzed; thus, the resulting number of measurements per age group, categorized by period (former vs. recent), were: U13 ($n = 672$ vs. $n = 964$), U14 (713 vs. 906), U15 (570 vs. 869), U16 (427 vs. 740), U17 (357 vs. 482), and U18 (208 vs. 282).

## 2.4. Statistical analyses

Outliers displaying $z$-scores <−4.0 and >4.0 were rejected for each age group and period separately (33).

Some confounding categorical and continuous variables were defined to reduce the bias in the estimation of the decade effect. Categorical variables included were the total number of *pretests* ("0" = no pretest, "1" = 1 pretest, "2" ≥ 2 pretests), the time *interval* between test and pretest ("0" = no pretest, "1" ≤ half a year, "2" ≥ one year), and the *location* of the development center or of the academy (i.e., 9 locations at U13 and U14, 12 locations at U15 to U18). Continuous covariates included were *exact age* (0.01 years), *height* (1 cm), and *body mass* (0.1 kg).

To identify the overall impacts of these confounders on the fitness performance, a multivariate analysis of covariance (MANCOVA) was performed for each age group separately, with *pretests*, *interval* (only U15 to U18), *location*, and *period* as the between-subjects variables, with *exact age*, *height*, and *body mass* as covariates, and with all fitness tests as the dependent variables. Partial eta squared ($\eta^2_P$) was computed and the significance level was set at $p < 0.05$.

For the matching procedure, a one-dimensional PS was estimated by means of logistic regression (34) using the decade as the outcome variable, and the confounding variables (i.e., covariates) as the predictors to create a matched sample of players from the former period (i.e., 2002 to 2005) and similar sample of players from the recent period (i.e., 2012 to 2015). After calculating the PS for each age group separately, the actual matching on these estimated scores commenced. A 1:1 nearest neighbor matching was applied in order to find the best possible matched groups (35), where each individual of the recent group was matched to that individual of the former group with the respective closest PS. To avoid poor matches, a caliper (i.e., the maximum distance permitted between matched individuals (36) of 0.25 standard deviations of the linear PS (37) was implemented and adjusted for each age group separately (U13 = 0.031; U14 = 0.035; U15 = 0.040; U16 = 0.054; U17 = 0.045; U18 = 0.060). Since each individual can be considered only once for pairing, a random selection order has been selected (38). In a further step, quality checks of the resulting matched samples were assessed by numerical (e.g., standardized differences of the means of the PS), and graphical (e.g., histograms of the PS before and after matching) diagnostics (35, 37, 39). Moreover, chi-squared tests on *pretests*, *interval*, and *location* as well as independent *t*-tests on *PS*, *exact age*, *height*, and *body mass* were conducted to assess the covariate balance before and after matching. Cramer's $V$ ($V$) and Cohen's $d$ ($d$) were calculated and the significance level was set at $p < 0.05$.

Since small random differences in the confounding variables may still remain even after matching, the subjects should still be treated as independent (40). Thus, and because of lower type-I error, independent samples *t*-tests using a significance level of 0.05 were performed to analyze the effect of the decade on the fitness characteristics. Since the order in which the treated individuals were selected into the matching process has an effect on the quality of the matches (41), the matching procedure, the quality checks and the subsequent inferential statistics (i.e., independent *t*-tests) were repeated 10 times for each age group. Analogous to the pooling phase of the multiple imputation approach described in Enders (42), age-group specific means (i.e., the arithmetic average of the 10 sampling means) and total variances (i.e., summing up the within-imputation variance, the between-imputation variance, and the sampling variance of the mean) were calculated for each four-year period. Cohen's $d$ was computed corresponding to the formula for between-subjects designs described in Lakens (43), and was classified as trivial ($d < 0.2$), small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$), respectively (44).

The PS matching was performed in IBM SPSS statistics version 25.0 (SPSS Inc., Chicago, IL, United States) using the "psmatching 3.04"-program, which is a R plug-in based on the statistical software package R (Version 3.3.3, R Core Team, Auckland, New Zealand). A detailed installation description of "psmatching 3.04" as well as an operation manual for this particular SPSS extension software is described in Thoemmes (34). The subsequent inferential statistics were also executed with IBM SPSS, whereas graphics and descriptive evaluations were generated using Microsoft Office (Version 2016, Microsoft, Seattle, WA, United States).

## 3. Results

The main effects of *pretests*, *interval*, and *location* for all players on the fitness test performance within age group as well as the influence of the covariables *exact age*, *height*, and *body mass* are displayed in **Table 1**. Main effects were found for *pretests* ($\eta^2_P = 0.022–0.086$, $p \leq 0.038$; except for U15-U16), and *location* ($\eta^2_P = 0.021–0.056$, $p < 0.001$). Additionally, all covariables (*exact age*, $\eta^2_P = 0.019–0.035$, $p \leq 0.028$; *height*, $\eta^2_P = 0.041–0.086$, $p \leq 0.021$; *body mass*, $\eta^2_P = 0.151–0.293$, $p < 0.001$) influenced the fitness performance, except for *exact age* at U17 and U18 level.

Descriptive and inferential analyses of categorical and continuous covariates within age group in the original dataset as well as in the matched dataset are presented in **Tables 2**, **3**. Differences between former and recent players were found for *pretests* ($V = 0.071–0.254$, $p \leq 0.027$), *interval* ($V = 0.085–0.161$, $p \leq 0.047$; except for U18), and *location* ($V = 0.154–0.355$, $p < 0.001$) in the original dataset across all age groups. In addition, pre-matching differences within age group between the two periods were found for *exact age* (U13 to U14, $d = 0.185–0.303$, $p < 0.001$; U15 to U18, $d = -0.287$ to $-0.562$, $p < 0.001$), *height* ($d = 0.264–0.320$, $p < 0.001$; except for U15 to U18), and *body mass* (U13 to U14, $d = 0.115–0.183$, $p \leq 0.022$; U16 to U17, $d = -0.199$ to $-0.238$, $p \leq 0.004$; except for U15 and U18) as well as for the *propensity score* ($d = -0.602$ to $-1.155$, $p < 0.001$).

The subsequent matching procedure resulted in 587, 573, 475, 325, 262, and 129 players per period in U13, U14, U15, U16, U17, and U18, respectively. After matching, the balance in all categorical covariates (*pretests*, $V = 0.002–0.043$, $p \geq 0.785$; *interval*, $V = 0.003–0.050$, $p \geq 0.724$; *location*, $V = 0.018–0.068$, $p \geq 0.997$) and in all continuous variables (*exact age*, $d = -0.049–0.018$, $p \geq 0.693$; *height*, $d = -0.020–0.017$, $p \geq 0.789$; *body mass*, $d = -0.016–0.024$, $p \geq 0.714$; *PS*, $d = -0.003–0.000$, $p \geq 0.982$) improved substantially between the two periods throughout all six age groups (**Tables 2**, **3**).

TABLE 1 Results of the MANCOVA of all players within age group: effects of pretests, interval, location, and period on fitness performance, controlled for exact age, height, and body mass.

| | Fixed factors | Wilks' lambda | F | df | *p* | $\eta^2_P$ | Covariables | Wilks' lambda | F | df | *p* | $\eta^2_P$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U13 | Pretests | 0.978 | 3.143 | 11, 1,557 | <0.001 | 0.022 | Exact age | 0.965 | 5.095 | 11, 1,557 | <0.001 | 0.035 |
| | Location | 0.841 | 3.103 | 88, 10,219 | <0.001 | 0.021 | Height | 0.914 | 13.365 | 11, 1,557 | <0.001 | 0.086 |
| | Period | 0.975 | 3.665 | 11, 1,557 | <0.001 | 0.025 | Body mass | 0.849 | 25.241 | 11, 1,557 | <0.001 | 0.151 |
| U14 | Pretests | 0.914 | 13.108 | 11, 1,539 | <0.001 | 0.086 | Exact age | 0.981 | 2.734 | 11, 1,539 | 0.002 | 0.019 |
| | Location | 0.644 | 7.957 | 88, 10,101 | <0.001 | 0.053 | Height | 0.930 | 10.463 | 11, 1,539 | <0.001 | 0.070 |
| | Period | 0.854 | 23.834 | 11, 1,539 | <0.001 | 0.146 | Body mass | 0.780 | 39.394 | 11, 1,539 | <0.001 | 0.220 |
| U15 | Pretests | 0.982 | 1.717 | 12, 1,125 | 0.058 | 0.018 | Exact age | 0.970 | 2.912 | 12, 1,125 | 0.001 | 0.030 |
| | Interval | 0.986 | 1.292 | 12, 1,125 | 0.217 | 0.014 | Height | 0.940 | 5.937 | 12, 1,125 | <0.001 | 0.060 |
| | Location | 0.663 | 3.595 | 132, 9,225 | <0.001 | 0.037 | Body mass | 0.712 | 37.964 | 12, 1,125 | <0.001 | 0.288 |
| | Period | 0.968 | 3.064 | 12, 1,125 | <0.001 | 0.032 | | | | | | |
| U16 | Pretests | 0.983 | 1.364 | 12, 973 | 0.177 | 0.017 | Exact age | 0.977 | 1.930 | 12, 973 | 0.028 | 0.023 |
| | Interval | 0.994 | 0.470 | 12, 973 | 0.933 | 0.006 | Height | 0.959 | 3.467 | 12, 973 | <0.001 | 0.041 |
| | Location | 0.739 | 2.272 | 132, 7,981 | <0.001 | 0.027 | Body mass | 0.707 | 33.671 | 12, 973 | <0.001 | 0.293 |
| | Period | 0.979 | 1.765 | 12, 973 | 0.050 | 0.021 | | | | | | |
| U17 | Pretests | 0.968 | 1.845 | 12, 671 | 0.038 | 0.032 | Exact age | 0.981 | 1.105 | 12, 671 | 0.353 | 0.019 |
| | Interval | 0.988 | 0.670 | 12, 671 | 0.782 | 0.012 | Height | 0.938 | 3.707 | 12, 671 | <0.001 | 0.062 |
| | Location | 0.661 | 2.165 | 132, 5,509 | <0.001 | 0.037 | Body mass | 0.765 | 17.199 | 12, 671 | <0.001 | 0.235 |
| | Period | 0.961 | 2.268 | 12, 671 | 0.008 | 0.039 | | | | | | |
| U18 | Pretests | 0.940 | 1.965 | 12, 367 | 0.026 | 0.060 | Exact age | 0.980 | 0.624 | 12, 367 | 0.822 | 0.020 |
| | Interval | 0.964 | 1.135 | 12, 367 | 0.330 | 0.036 | Height | 0.938 | 2.029 | 12, 367 | 0.021 | 0.062 |
| | Location | 0.533 | 1.831 | 132, 3,021 | <0.001 | 0.056 | Body mass | 0.826 | 6.431 | 12, 367 | <0.001 | 0.174 |
| | Period | 0.961 | 1.246 | 12, 367 | 0.250 | 0.039 | | | | | | |

**Figure 1** visualizes performance increases (positive Cohen's *d*), decreases (negative Cohen's *d*) and statistical significances between former (2002 to 2005) and recent (2012 to 2015) Austrian soccer players at YDC (U13 to U14) and academy level (U15 to U18).

## 3.1. Youth development center

Regarding the factor "speed", after controlling for the covariates, recent YDC players showed better performances in *5 m* (0.01–0.02 s, $d = 0.187–0.297$, $p \leq 0.001$), *10 m* (0.02–0.03 s, $d = 0.233–0.290$, $p < 0.001$), and *20 m sprint* (0.02–0.03 s, $d = 0.154–0.196$, $p \leq 0.008$). Only trivial effects of decade were found for *shuttle sprint* ($p \geq 0.202$) at YDC level (**Table 4**).

With respect to "coordination", trivial to small enhancements of recent YDC players were reported for *reaction test* (11–29 ms, $d = 0.111–0.288$, $p \leq 0.062$). Trivial changes over the decade were computed for *hurdles agility run* ($p \geq 0.391$) at U13 to U14 and *foot tapping* ($p = 0.909$) at U13. The latter even displayed a performance decrease over the years at U14 (−0.2 Hz, $d = -0.208$, $p < 0.001$) (**Table 5**).

Concerning "power and flexibility", former YDC players outperformed the recent players in the *medicine ball throw* (−0.3 m to −0.5 m, $p < 0.001$) and *sit-and-reach* (−2.8 to −3.2 cm, $p < 0.001$), with small effects in upper-limb power ($d = -0.278$ to $-0.347$) and medium effects in flexibility ($d = -0.474$ to $-0.589$). Only trivial effects of decade were measured in *countermovement jump* ($p \geq 0.044$) and *drop jump* ($p \geq 0.314$) in both age groups (**Table 6**).

## 3.2. Youth soccer academy

With reference to "speed", recent academy players outperformed the former players within all age groups at *5 m* (0.01–0.03 s, $d = 0.241–0.467$, $p \leq 0.054$), *10 m* (0.02–0.04 s, $d = 0.267–0.476$, $p \leq 0.033$), *20 m* (0.04–0.07 s, $d = 0.356–0.437$, $p \leq 0.002$), and *shuttle sprint* (0.08–0.20 s, $d = 0.172–0.466$, $p \leq 0.029$). The largest effect sizes were detected at U15 level for the *linear sprint* (*5 m*, $d = 0.467$; *10 m*, $d = 0.476$; *20 m*, $d = 0.437$), and at U18 for the *shuttle sprint* ($d = 0.466$) (**Table 4**).

Regarding "coordination and endurance", *hurdles agility run* improved over the decade across all age groups (0.19–0.23 s, $d = 0.269–0.340$, $p \leq 0.008$), except for U16 ($p \geq 0.118$), whereas *reaction test* performance enhanced solely at U15 (25 ms, $d = 0.310$, $p < 0.001$). Only trivial effects over time were found for *foot tapping* ($d = -0.170–0.115$, $p = 0.031–0.478$) and *endurance run* ($p \geq 0.443$) at academy level (**Table 5**).

With respect to "power and flexibility", former players were more flexible across academy years (−1.0 to −2.4 cm, $p \leq 0.020$; except for U18), with $d = -0.151$ to $-0.357$. In addition, trivial to small performance decreases were shown in *drop jump* at U16 to U18 (−0.35 to −0.53, $d = -0.150$ to $-0.203$, $p \leq 0.109$). Only trivial effects over the decade were detected in *countermovement jump* ($p \geq 0.134$) and *medicine ball throw* ($p \geq 0.124$) across all academy age groups (**Table 6**).

# 4. Discussion

We evaluated whether the fitness level of elite Austrian youth soccer players has changed over one decade under statistical

TABLE 2 Descriptive (distribution) and inferential (former vs. recent period) statistics of the categorical covariates before and after propensity score matching.

| | Before propensity score matching | | | | | | | | | | | | After propensity score matching | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 to 2005 | | | | 2012 to 2015 | | | | Chi² | *p* | Cramer's *V* | | 2002 to 2005 | | | | 2012 to 2015 | | | | Chi² | *p* | Cramer's *V* | |
| U13 | *n* = 672 | | | | *n* = 964 | | | | | | | | *n* = 587 | | | | *n* = 587 | | | | | | | |
| Pretests | **0** | **1** | | | **0** | **1** | | | 49.593 | <0.001 | 0.174 | | **0** | **1** | | | **0** | **1** | | | 0.004 | 0.948 | 0.002 | |
| (%) | 95 | 5 | | | 84 | 16 | | | | | | | 95 | 5 | | | 95 | 5 | | | | | | |
| Location (%) | **1** | **2** | **3** | | **1** | **2** | **3** | | 38.978 | <0.001 | 0.154 | | **1** | **2** | **3** | | **1** | **2** | **3** | | 1.196 | 0.997 | 0.032 | |
| | 12 | 11 | 18 | | 9 | 8 | 17 | | | | | | 11 | 10 | 19 | | 12 | 10 | 20 | | | | | |
| | **4** | **5** | **6** | | **4** | **5** | **6** | | | | | | **4** | **5** | **6** | | **4** | **5** | **6** | | | | | |
| | 13 | 9 | 14 | | 8 | 13 | 11 | | | | | | 11 | 10 | 14 | | 10 | 10 | 15 | | | | | |
| | **7** | **8** | **9** | | **7** | **8** | **9** | | | | | | **7** | **8** | **9** | | **7** | **8** | **9** | | | | | |
| | 8 | 8 | 7 | | 14 | 11 | 10 | | | | | | 7 | 9 | 8 | | 6 | 9 | 8 | | | | | |
| U14 | *n* = 713 | | | | *n* = 906 | | | | | | | | *n* = 573 | | | | *n* = 573 | | | | | | | |
| Pretests | **0** | **1** | | | **0** | **1** | | | 12.228 | <0.001 | 0.087 | | **0** | **1** | | | **0** | **1** | | | 0.019 | 0.890 | 0.004 | |
| (%) | 43 | 57 | | | 35 | 65 | | | | | | | 40 | 60 | | | 40 | 60 | | | | | | |
| Location (%) | **1** | **2** | **3** | | **1** | **2** | **3** | | 117.686 | <0.001 | 0.270 | | **1** | **2** | **3** | | **1** | **2** | **3** | | 0.374 | 1.000 | 0.018 | |
| | 11 | 12 | 15 | | 12 | 10 | 17 | | | | | | 13 | 12 | 18 | | 13 | 12 | 18 | | | | | |
| | **4** | **5** | **6** | | **4** | **5** | **6** | | | | | | **4** | **5** | **6** | | **4** | **5** | **6** | | | | | |
| | 16 | 11 | 15 | | 11 | 16 | 13 | | | | | | 13 | 13 | 17 | | 13 | 13 | 16 | | | | | |
| | **7** | **8** | **9** | | **7** | **8** | **9** | | | | | | **7** | **8** | **9** | | **7** | **8** | **9** | | | | | |
| | 8 | 5 | 7 | | 0 | 12 | 10 | | | | | | 0 | 6 | 8 | | 0 | 6 | 8 | | | | | |
| U15 | *n* = 570 | | | | *n* = 869 | | | | | | | | *n* = 475 | | | | *n* = 475 | | | | | | | |
| Pretests | **0** | **1** | **2** | | **0** | **1** | **2** | | 7.219 | 0.027 | 0.071 | | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.201 | 0.904 | 0.015 | |
| (%) | 22 | 40 | 38 | | 19 | 35 | 46 | | | | | | 19 | 38 | 42 | | 20 | 38 | 42 | | | | | |
| Interval | **0** | **1** | **2** | | **0** | **1** | **2** | | 11.863 | 0.003 | 0.091 | | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.203 | 0.903 | 0.015 | |
| (%) | 22 | 57 | 21 | | 19 | 66 | 15 | | | | | | 19 | 61 | 20 | | 20 | 60 | 19 | | | | | |
| Location (%) | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 82.437 | <0.001 | 0.239 | | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 0.733 | 1.000 | 0.028 | |
| | 2 | 10 | 9 | 5 | 8 | 8 | 9 | 6 | | | | | 3 | 10 | 9 | 5 | 3 | 10 | 9 | 4 | | | | |
| | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | |
| | 11 | 11 | 24 | 5 | 9 | 9 | 10 | 9 | | | | | 12 | 11 | 18 | 5 | 12 | 11 | 18 | 6 | | | | |
| | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | |
| | 5 | 5 | 10 | 4 | 7 | 8 | 10 | 6 | | | | | 6 | 6 | 11 | 4 | 7 | 5 | 10 | 4 | | | | |
| U16 | *n* = 427 | | | | *n* = 740 | | | | | | | | *n* = 325 | | | | *n* = 325 | | | | | | | |
| Pretests | **0** | **1** | **2** | | **0** | **1** | **2** | | 73.219 | <0.001 | 0.250 | | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.022 | 0.989 | 0.006 | |
| (%) | 9 | 19 | 71 | | 2 | 7 | 91 | | | | | | 5 | 12 | 83 | | 5 | 12 | 83 | | | | | |
| Interval | **0** | **1** | **2** | | **0** | **1** | **2** | | 30.084 | <0.001 | 0.161 | | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.006 | 0.997 | 0.003 | |
| (%) | 9 | 74 | 17 | | 2 | 83 | 15 | | | | | | 5 | 79 | 16 | | 5 | 79 | 16 | | | | | |
| Location (%) | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 77.108 | <0.001 | 0.257 | | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 0.396 | 1.000 | 0.025 | |
| | 13 | 11 | 7 | 4 | 8 | 8 | 10 | 7 | | | | | 11 | 11 | 8 | 6 | 12 | 11 | 8 | 6 | | | | |
| | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | |
| | 9 | 8 | 21 | 7 | 8 | 9 | 9 | 10 | | | | | 10 | 8 | 17 | 7 | 10 | 8 | 16 | 6 | | | | |
| | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | |

(*Continued*)





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TABLE 2 Continued

| | Before propensity score matching | | | | | | | | | | | After propensity score matching | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 to 2005 | | | | 2012 to 2015 | | | | Chi² | *p* | Cramer's *V* | 2002 to 2005 | | | | 2012 to 2015 | | | | Chi² | *p* | Cramer's *V* |
| | 3 | 3 | 10 | 4 | 8 | 9 | 10 | 6 | | | | 4 | 4 | 11 | 5 | 4 | 4 | 12 | 5 | | | |
| U17 | *n* = 357 | | | | *n* = 482 | | | | | | | *n* = 262 | | | | *n* = 262 | | | | | | |
| Pretests | **0** | **1** | **2** | | **0** | **1** | **2** | | 21.433 | <0.001 | 0.160 | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.060 | 0.971 | 0.011 |
| (%) | 6 | 9 | 84 | | 3 | 3 | 94 | | | | | 4 | 5 | 91 | | 5 | 5 | 91 | | | | |
| Interval | **0** | **1** | **2** | | **0** | **1** | **2** | | 6.102 | 0.047 | 0.085 | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.022 | 0.989 | 0.006 |
| (%) | 6 | 78 | 15 | | 3 | 81 | 16 | | | | | 4 | 81 | 15 | | 5 | 81 | 15 | | | | |
| Location (%) | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 39.464 | <0.001 | 0.217 | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 0.512 | 1.000 | 0.031 |
| | 10 | 11 | 6 | 4 | 9 | 9 | 9 | 5 | | | | 9 | 9 | 8 | 5 | 10 | 10 | 9 | 5 | | | |
| | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | |
| | 12 | 10 | 19 | 9 | 9 | 10 | 9 | 11 | | | | 11 | 10 | 15 | 10 | 11 | 9 | 14 | 10 | | | |
| | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | |
| | 3 | 4 | 7 | 6 | 6 | 9 | 10 | 5 | | | | 3 | 5 | 9 | 6 | 4 | 5 | 9 | 6 | | | |
| U18 | *n* = 208 | | | | *n* = 282 | | | | | | | *n* = 129 | | | | *n* = 129 | | | | | | |
| Pretests | **0** | **1** | **2** | | **0** | **1** | **2** | | 31.533 | <0.001 | 0.254 | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.484 | 0.785 | 0.043 |
| (%) | 2 | 14 | 84 | | 2 | 1 | 97 | | | | | 3 | 2 | 95 | | 2 | 2 | 96 | | | | |
| Interval | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.759 | 0.684 | 0.039 | **0** | **1** | **2** | | **0** | **1** | **2** | | 0.647 | 0.724 | 0.050 |
| (%) | 2 | 77 | 20 | | 2 | 75 | 23 | | | | | 3 | 79 | 18 | | 2 | 78 | 21 | | | | |
| Location (%) | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 61.849 | <0.001 | 0.355 | **1** | **2** | **3** | **4** | **1** | **2** | **3** | **4** | 1.201 | 1.000 | 0.068 |
| | 14 | 9 | 3 | 3 | 12 | 8 | 9 | 2 | | | | 16 | 10 | 3 | 3 | 17 | 8 | 3 | 2 | | | |
| | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | | **5** | **6** | **7** | **8** | **5** | **6** | **7** | **8** | | | |
| | 13 | 13 | 16 | 7 | 10 | 7 | 3 | 18 | | | | 14 | 12 | 5 | 10 | 15 | 11 | 7 | 9 | | | |
| | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | | **9** | **10** | **11** | **12** | **9** | **10** | **11** | **12** | | | |
| | 3 | 4 | 13 | 2 | 8 | 8 | 9 | 7 | | | | 5 | 6 | 13 | 4 | 5 | 4 | 14 | 5 | | | |

Bold values indicate the values of each covariate.





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TABLE 3 Descriptive (M ± SD) and inferential (former vs. current period) statistics of the propensity score and the continuous covariates before and after propensity score matching.

| | Before propensity score matching | | | | | After propensity score matching (pooled estimates) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 to 2005 | 2012 to 2015 | *t*-statistic | *p* | Cohen's *d* | 2002 to 2005 | 2012 to 2015 | *t*-statistic | *p* | Cohen's *d* |
| U13 | *n* = 672 | *n* = 964 | | | | *n* = 587 | *n* = 587 | | | |
| Propensity score | 0.46 ± 0.12 | 0.38 ± 0.14 | −12.286 | <0.001 | −0.602 | 0.44 ± 0.12 | 0.44 ± 0.12 | −0.009 | 0.993 | −0.001 |
| Exact age (yrs.) | 12.32 ± 0.27 | 12.42 ± 0.35 | 6.294 | <0.001 | 0.303 | 12.33 ± 0.30 | 12.33 ± 0.34 | −0.029 | 0.977 | −0.002 |
| Height (cm) | 151.4 ± 7.2 | 153.7 ± 7.6 | 6.377 | <0.001 | 0.320 | 151.8 ± 7.5 | 151.7 ± 7.6 | −0.206 | 0.837 | −0.012 |
| Body mass (kg) | 41.0 ± 6.5 | 42.3 ± 6.8 | 3.641 | <0.001 | 0.183 | 41.2 ± 6.8 | 41.1 ± 6.7 | −0.275 | 0.784 | −0.016 |
| U14 | *n* = 713 | *n* = 906 | | | | *n* = 573 | *n* = 573 | | | |
| Propensity score | 0.50 ± 0.19 | 0.39 ± 0.12 | −13.093 | <0.001 | −0.688 | 0.43 ± 0.11 | 0.43 ± 0.11 | −0.014 | 0.989 | −0.001 |
| Exact age (yrs.) | 13.30 ± 0.30 | 13.35 ± 0.29 | 3.690 | <0.001 | 0.185 | 13.33 ± 0.30 | 13.33 ± 0.33 | −0.119 | 0.905 | −0.007 |
| Height (cm) | 158.3 ± 8.6 | 160.5 ± 8.5 | 5.271 | <0.001 | 0.264 | 159.2 ± 8.5 | 159.1 ± 9.0 | −0.060 | 0.952 | −0.004 |
| Body mass (kg) | 47.0 ± 8.3 | 47.9 ± 8.2 | 2.288 | 0.022 | 0.115 | 47.5 ± 8.5 | 47.3 ± 9.8 | −0.263 | 0.793 | −0.016 |
| U15 | *n* = 570 | *n* = 869 | | | | *n* = 475 | *n* = 475 | | | |
| Propensity score | 0.47 ± 0.16 | 0.35 ± 0.16 | −13.867 | <0.001 | −0.747 | 0.43 ± 0.15 | 0.43 ± 0.15 | −0.007 | 0.995 | 0.000 |
| Exact age (yrs.) | 14.61 ± 0.37 | 14.52 ± 0.28 | −5.023 | <0.001 | −0.287 | 14.59 ± 0.40 | 14.59 ± 0.29 | 0.184 | 0.854 | 0.012 |
| Height (cm) | 169.6 ± 8.2 | 170.3 ± 7.9 | 1.457 | 0.145 | 0.079 | 169.7 ± 8.7 | 169.8 ± 8.5 | 0.268 | 0.789 | 0.017 |
| Body mass (kg) | 58.7 ± 9.6 | 58.1 ± 8.8 | −1.275 | 0.203 | −0.069 | 58.3 ± 10.0 | 58.5 ± 9.8 | 0.367 | 0.714 | 0.024 |
| U16 | *n* = 427 | *n* = 740 | | | | *n* = 325 | *n* = 325 | | | |
| Propensity score | 0.49 ± 0.22 | 0.29 ± 18 | −16.005 | <0.001 | −1.024 | 0.41 ± 0.18 | 0.41 ± 0.18 | −0.016 | 0.987 | −0.001 |
| Exact age (yrs.) | 15.68 ± 0.29 | 15.52 ± 0.28 | −9.244 | <0.001 | −0.562 | 15.63 ± 0.31 | 15.63 ± 0.27 | −0.220 | 0.826 | −0.017 |
| Height (cm) | 175.1 ± 6.3 | 174.8 ± 6.6 | −0.748 | 0.455 | −0.045 | 175.0 ± 6.6 | 174.9 ± 8.2 | −0.225 | 0.822 | −0.018 |
| Body mass (kg) | 65.9 ± 7.7 | 64.0 ± 7.8 | −3.910 | <0.001 | −0.238 | 65.4 ± 7.9 | 65.4 ± 10.3 | 0.048 | 0.961 | 0.004 |
| U17 | *n* = 357 | *n* = 482 | | | | *n* = 262 | *n* = 262 | | | |
| Propensity score | 0.50 ± 0.18 | 0.37 ± 0.16 | −11.202 | <0.001 | −0.794 | 0.44 ± 0.16 | 0.44 ± 0.16 | −0.019 | 0.985 | −0.002 |
| Exact age (yrs.) | 16.66 ± 0.29 | 16.51 ± 0.28 | −7.249 | <0.001 | −0.506 | 16.60 ± 0.29 | 16.60 ± 0.26 | 0.206 | 0.837 | 0.018 |
| Height (cm) | 177.6 ± 5.8 | 177.3 ± 6.2 | −0.869 | 0.385 | −0.061 | 177.6 ± 6.3 | 177.5 ± 7.3 | −0.233 | 0.816 | −0.020 |
| Body mass (kg) | 69.5 ± 7.2 | 68.1 ± 7.0 | −2.854 | 0.004 | −0.199 | 69.1 ± 7.5 | 68.9 ± 7.6 | −0.188 | 0.851 | −0.016 |
| U18 | *n* = 208 | *n* = 282 | | | | *n* = 129 | *n* = 129 | | | |
| Propensity score | 0.56 ± 0.24 | 0.32 ± 0.18 | −12.133 | <0.001 | −1.155 | 0.43 ± 0.19 | 0.43 ± 0.19 | −0.022 | 0.982 | −0.003 |
| Exact age (yrs.) | 17.64 ± 0.29 | 17.50 ± 0.27 | −5.313 | <0.001 | −0.491 | 17.58 ± 0.30 | 17.56 ± 0.29 | −0.395 | 0.693 | −0.049 |
| Height (cm) | 178.5 ± 5.7 | 178.8 ± 6.1 | 0.588 | 0.557 | 0.054 | 178.8 ± 6.5 | 178.7 ± 8.3 | −0.127 | 0.899 | −0.016 |
| Body mass (kg) | 71.3 ± 6.7 | 71.0 ± 6.6 | −0.417 | 0.677 | −0.038 | 71.3 ± 7.2 | 71.4 ± 8.2 | 0.047 | 0.963 | 0.006 |

control for players' height, body mass and exact age as well as the total number of pretests, the time interval between pretests and the location of the test. Superior performances of recent players were found for linear sprint speed across all age categories as well as for general agility and change-of-direction speed at academy level. In addition, reaction speed increased over the decade most notably at U13 and U15 level. However, flexibility decreased over time in almost all age categories and upper-limb power decreased at YDC level.

The improvements of sprint speed in elite Austrian youth soccer players over the years fit well into current prospects that soccer "is likely to be played at higher speeds in the future" (45). Evolutions in game speed and the shift to shorter, more intense play periods (10) as well as enhancements of maximum running speed and higher proportions of explosive sprints (11) underline that a certain level of sprint speed is indispensable within the modern game. Besides linear sprint, the observed enhancements at academy level in general agility and in the ability to perform rapid changes in direction may be ascribed to progresses concerning training specificity (46) as contemporary training approaches integrate physical work into tactical and technical work by the use of small sided games (47) and soccer-specific change-of-direction drills (48, 49). Nevertheless, supplementing small sided games and soccer-specific drills with isolated strength, power and speed training may be most beneficial during the academy years (50, 51) to enhance both the ability to perform single maximal efforts (i.e., acceleration, deceleration, change-of-direction) and the ability of repeating such maximal efforts (52). The prognostic relevance of both linear and change-of-direction speed as well as repeated sprint ability and endurance in terms of talent identification (53) further underlines the need for both fast and well-conditioned players within the modern game.

Furthermore, recent players showed superior multi-choice reaction time performance over the years, especially at U13 and U15 level. These two age groups mark decisive transitions within the Austrian talent promotion system, where players are selected into either YDC (U13) or youth soccer academies (U15). Growing evidence and awareness of the impact of cognitive performance on the success in ball sports (e.g., 54) make it very plausible that coaches favor players with improved cognitive functions (e.g., faster decision making skills) and better game reading skills (e.g., responding more rapidly to a relevant sign) nowadays (10, 55, 56). Besides these positive performance trends over the investigated period, recent players demonstrate inferior general flexibility compared to former ones, ranging from small to medium Cohen's *d* throughout all age categories. Considering

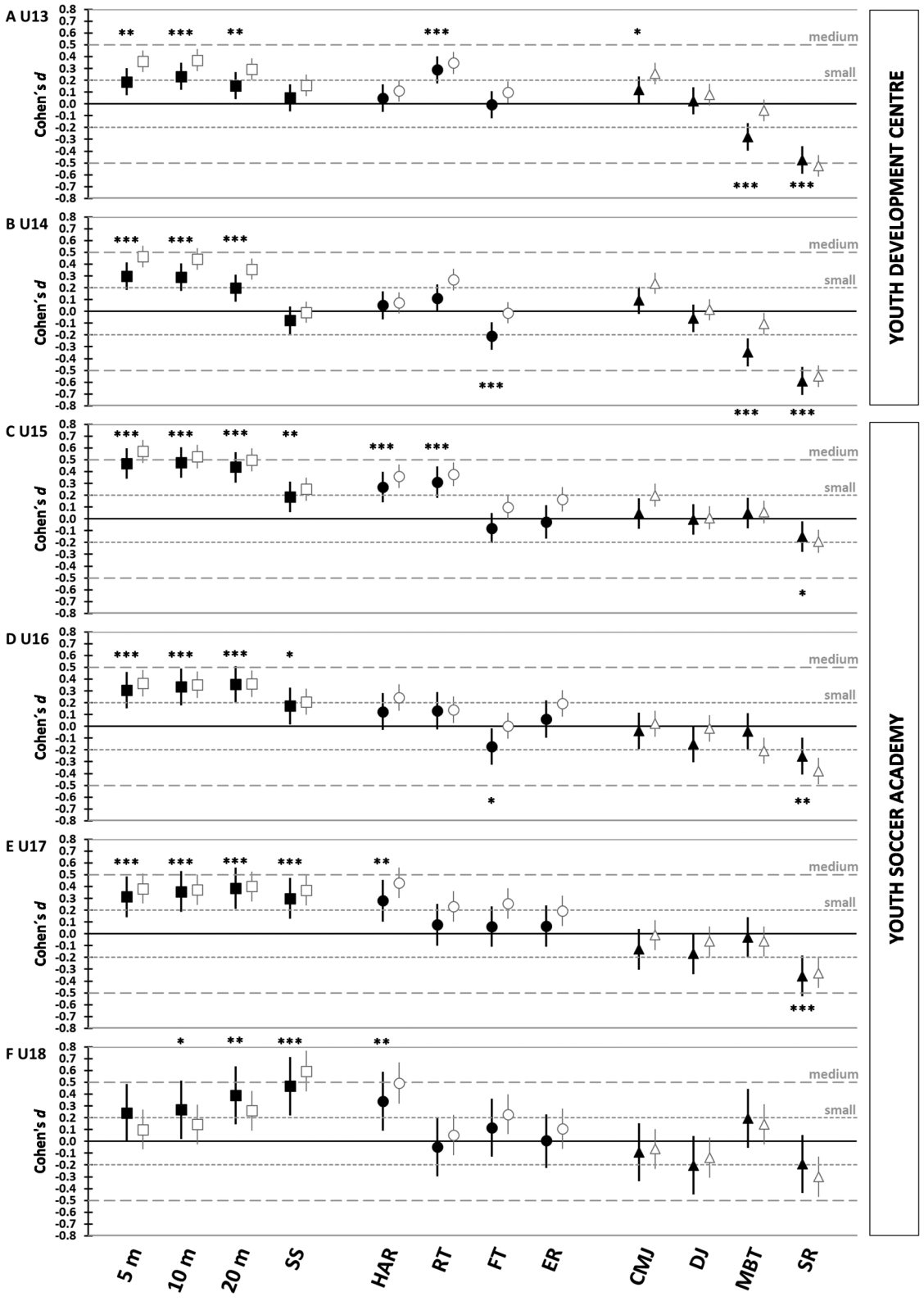


FIGURE 1
Changes (Cohen's *d*) in "speed" (square), "coordination and endurance" (circle), and "power and flexibility" (triangle) between former (2002 to 2005) and current (2012 to 2015) U13 (**A**), U14 (**B**), U15 (**C**), U16 (**D**), U17 (**E**), and U18 (**F**) soccer players after matching (full symbols) compared to Gonaus et al. (19) (empty symbols). 5/10/20 m = *5/10/20 m sprint*, SS = *5 × 10 m shuttle sprint*, HAR = *hurdles agility run*, RT = *reaction test*, FT = *foot tapping*, ER = *20 m multi-stage endurance run*, CMJ = *countermovement jump*, DJ = *drop jump*, MBT = *2 kg overhead medicine ball throw*, SR = *sit-and-reach*. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Positive Cohen's *d* values indicate superior performance of current players, whereas negative Cohen's *d* values denote performance decreases.

TABLE 4 Descriptive, M ± SD (n), and inferential analyses for the factor "speed".

| | 2002 to 2005 | 2012 to 2015 | Mean difference [95% CI] | *t*-statistic | *p* | Cohen's *d* [95% CI] |
|---|---|---|---|---|---|---|
| 5 m sprint (s) | | | | | | |
| U13 | 1.17 ± 0.07 (584) | 1.16 ± 0.06 (584) | 0.01 [0.00; 0.02] | 3.197 | 0.001 | 0.187 [0.072; 0.302] |
| U14 | 1.14 ± 0.07 (573) | 1.12 ± 0.06 (573) | 0.02 [0.01; 0.03] | 5.021 | <0.001 | 0.297 [0.180; 0.413] |
| U15 | 1.10 ± 0.07 (475) | 1.06 ± 0.06 (475) | 0.03 [0.02; 0.04] | 7.191 | <0.001 | 0.467 [0.338; 0.596] |
| U16 | 1.06 ± 0.07 (325) | 1.04 ± 0.06 (325) | 0.02 [0.01; 0.03] | 3.904 | <0.001 | 0.306 [0.152; 0.461] |
| U17 | 1.05 ± 0.07 (262) | 1.03 ± 0.06 (262) | 0.02 [0.01; 0.03] | 3.578 | <0.001 | 0.313 [0.140; 0.485] |
| U18 | 1.04 ± 0.06 (129) | 1.03 ± 0.05 (129) | 0.01 [−0.00; 0.03] | 1.934 | 0.054 | 0.241 [−0.004; 0.486] |
| 10 m sprint (s) | | | | | | |
| U13 | 2.01 ± 0.10 (584) | 1.99 ± 0.09 (584) | 0.02 [0.01; 0.03] | 3.976 | <0.001 | 0.233 [0.118; 0.348] |
| U14 | 1.96 ± 0.09 (573) | 1.93 ± 0.09 (573) | 0.03 [0.02; 0.04] | 4.902 | <0.001 | 0.290 [0.173; 0.406] |
| U15 | 1.87 ± 0.10 (475) | 1.83 ± 0.08 (475) | 0.04 [0.03; 0.05] | 7.328 | <0.001 | 0.476 [0.346; 0.604] |
| U16 | 1.81 ± 0.09 (325) | 1.79 ± 0.08 (325) | 0.03 [0.02; 0.04] | 4.254 | <0.001 | 0.334 [0.179; 0.489] |
| U17 | 1.79 ± 0.09 (262) | 1.76 ± 0.07 (262) | 0.03 [0.01; 0.04] | 4.101 | <0.001 | 0.358 [0.185; 0.531] |
| U18 | 1.77 ± 0.07 (129) | 1.76 ± 0.06 (129) | 0.02 [0.00; 0.04] | 2.143 | 0.033 | 0.267 [0.021; 0.512] |
| 20 m sprint (s) | | | | | | |
| U13 | 3.51 ± 0.16 (584) | 3.49 ± 0.15 (584) | 0.02 [0.01; 0.04] | 2.638 | 0.008 | 0.154 [0.039; 0.269] |
| U14 | 3.41 ± 0.16 (573) | 3.38 ± 0.16 (573) | 0.03 [0.01; 0.05] | 3.327 | <0.001 | 0.196 [0.080; 0.312] |
| U15 | 3.24 ± 0.16 (475) | 3.17 ± 0.15 (475) | 0.07 [0.05; 0.09] | 6.736 | <0.001 | 0.437 [0.308; 0.566] |
| U16 | 3.12 ± 0.13 (325) | 3.08 ± 0.15 (325) | 0.05 [0.03; 0.07] | 4.534 | <0.001 | 0.356 [0.201; 0.511] |
| U17 | 3.07 ± 0.12 (262) | 3.03 ± 0.11 (262) | 0.04 [0.02; 0.06] | 4.409 | <0.001 | 0.385 [0.212; 0.558] |
| U18 | 3.05 ± 0.11 (129) | 3.01 ± 0.10 (129) | 0.04 [0.02; 0.07] | 3.130 | 0.002 | 0.390 [0.143; 0.636] |
| 5 × 10 m shuttle sprint (s) | | | | | | |
| U13 | 12.75 ± 0.57 (585) | 12.72 ± 0.57 (585) | 0.03 [−0.03; 0.09] | 0.898 | 0.369 | 0.053 [−0.062; 0.167] |
| U14 | 12.34 ± 0.53 (570) | 12.38 ± 0.55 (570) | −0.04 [−0.10; 0.02] | −1.275 | 0.202 | −0.076 [−0.192; 0.041] |
| U15 | 11.77 ± 0.52 (470) | 11.68 ± 0.48 (470) | 0.09 [0.03; 0.16] | 2.850 | 0.004 | 0.186 [0.058; 0.314] |
| U16 | 11.42 ± 0.47 (324) | 11.34 ± 0.45 (324) | 0.08 [0.01; 0.15] | 2.184 | 0.029 | 0.172 [0.017; 0.326] |
| U17 | 11.27 ± 0.41 (260) | 11.15 ± 0.41 (260) | 0.12 [0.05; 0.19] | 3.405 | <0.001 | 0.299 [0.126; 0.472] |
| U18 | 11.22 ± 0.41 (129) | 11.02 ± 0.45 (129) | 0.20 [0.09; 0.31] | 3.740 | <0.001 | 0.466 [0.218; 0.713] |

that a reduced hip flexion range of motion increases the likelihood for hamstring injuries (57) and that hamstring flexibility is a key factor for performing soccer-specific skills (58), dynamic warm-up programs including strength, balance and mobility exercises should be added before games or during training sessions to counter this negative trend (59).

Within the context of selection policies, relative age and biological maturation are often attributed to affect fitness performance at young ages (20, 21, 60) and thus, to influence selection decisions in favor of early born or, even more, early-matured players in elite youth soccer (61).

However, it is important to note that the impact of biological maturation is greater on fitness than on motor coordination skills (62) and that the effect of relative age and maturation should be recognized as independent constructs (63). Accordingly, the present MANCOVA showed a significant influence of the covariables *exact age, height* and *body mass* on the fitness performance. In addition, the number of *pretests*, e.g., representing potential learning effects (26) as well as the *location* of the YDC or academy, e.g., that coaches use different player recruitment criteria and strategies (28), significantly influenced the fitness outcome. Thus, the results of the MANCOVA served as the rational for controlling these variables via statistical matching.

The results of the subsequent PS matching showed that the matching led to an improved balance in all confounding variables (*exact age, height, body mass, pretests, interval, location*) between the two periods throughout all six age groups. Any statistical pre-matching differences of these confounders disappeared after the matching procedure. Appling the PS matching approach is rather unique in the talent development research, even though this established multivariate matched sampling method has received increased attention in medical research (64) and social sciences (65). The statistical procedure is typically applied in observational studies, when random assignment to condition is not feasible (66). It uses the PS as a single balancing variable to construct probabilistically equivalent groups on the relevant covariates (39), and thus to minimize the bias in the estimation of the treatment effect (35).

Compared to the original, non-matched dataset in Gonaus et al. (19), balancing this covariate distribution via PS matching resulted in rather similar outcomes. Even after controlling for *exact age, height, body mass, pretests, interval,* and *location*, recent Austrian youth soccer players were faster but less flexible than former players in all age groups. However, the size of the decade effects decreased especially at younger age groups when comparing the non-matched vs. the PS matched dataset: at U13 to U14 in *5 m* (0.360–0.463 vs. 0.187–0.297), *10 m* (0.371–0.443 vs. 0.233–0.290), and *20 m sprint* (0.294–0.358 vs. 0.154–0.196) as well as at U13 to U15 in *countermovement jump* (0.199–0.255 vs. 0.045–0.118). It is reasonable that the greater influence of the covariates on speed and lower-body power in younger age groups is primarily caused by age and maturity related factors, underpinning

TABLE 5 Descriptive, M ± SD (n), and inferential analyses for the factor "coordination and endurance".

| | 2002 to 2005 | 2012 to 2015 | Mean difference [95% CI] | *t*-statistic | *p* | Cohen's *d* [95% CI] |
|---|---|---|---|---|---|---|
| Hurdles agility run (s) | | | | | | |
| U13 | 12.95 ± 0.93 (582) | 12.90 ± 0.98 (582) | 0.05 [−0.06; 0.15] | 0.834 | 0.404 | 0.049 [−0.066; 0.164] |
| U14 | 12.57 ± 0.82 (565) | 12.52 ± 0.99 (565) | 0.05 [−0.06; 0.15] | 0.857 | 0.391 | 0.051 [−0.066; 0.168] |
| U15 | 12.02 ± 0.75 (468) | 11.82 ± 0.75 (468) | 0.20 [0.11; 0.29] | 4.112 | <0.001 | 0.269 [0.140; 0.398] |
| U16 | 11.53 ± 0.66 (316) | 11.45 ± 0.75 (316) | 0.09 [−0.02; 0.20] | 1.566 | 0.118 | 0.125 [−0.032; 0.281] |
| U17 | 11.37 ± 0.61 (251) | 11.18 ± 0.71 (251) | 0.19 [0.07; 0.30] | 3.133 | 0.002 | 0.280 [0.104; 0.455] |
| U18 | 11.30 ± 0.70 (125) | 11.06 ± 0.69 (125) | 0.23 [0.06; 0.41] | 2.682 | 0.008 | 0.340 [0.089; 0.589] |
| Reaction test (ms) | | | | | | |
| U13 | 760 ± 105 (585) | 731 ± 93 (585) | 29 [17; 40] | 4.927 | <0.001 | 0.288 [0.173; 0.403] |
| U14 | 686 ± 92 (567) | 675 ± 104 (567) | 11 [−1; 23] | 1.867 | 0.062 | 0.111 [−0.006; 0.227] |
| U15 | 628 ± 92 (440) | 603 ± 70 (440) | 25 [15; 36] | 4.590 | <0.001 | 0.310 [0.177; 0.442] |
| U16 | 578 ± 79 (306) | 569 ± 60 (306) | 9 [−1; 20] | 1.643 | 0.101 | 0.133 [−0.026; 0.291] |
| U17 | 563 ± 75 (248) | 558 ± 57 (248) | 5 [−6; 17] | 0.856 | 0.392 | 0.077 [−0.099; 0.253] |
| U18 | 551 ± 62 (124) | 554 ± 61 (124) | −3 [−18; 12] | −0.354 | 0.724 | −0.045 [−0.294; 0.204] |
| Foot tapping (Hz) | | | | | | |
| U13 | 11.1 ± 1.1 (585) | 11.0 ± 1.2 (585) | −0.0 [−0.1; 0.1] | −0.114 | 0.909 | −0.007 [−0.121; 0.108] |
| U14 | 11.7 ± 1.1 (572) | 11.5 ± 1.2 (572) | −0.2 [−0.4; −0.1] | −3.513 | <0.001 | −0.208 [−0.324; −0.091] |
| U15 | 12.7 ± 1.3 (475) | 12.6 ± 1.2 (475) | −0.1 [−0.3; 0.1] | −1.216 | 0.224 | −0.079 [−0.206; 0.048] |
| U16 | 13.4 ± 1.2 (323) | 13.2 ± 1.2 (323) | −0.2 [−0.4; −0.0] | −2.165 | 0.031 | −0.170 [−0.325; −0.016] |
| U17 | 13.6 ± 1.3 (262) | 13.7 ± 1.2 (262) | 0.1 [−0.1; 0.3] | 0.710 | 0.478 | 0.062 [−0.109; 0.233] |
| U18 | 13.7 ± 1.2 (129) | 13.9 ± 1.4 (129) | 0.2 [−0.2; 0.5] | 0.925 | 0.356 | 0.115 [−0.129; 0.360] |
| 20 m multi-stage endurance run (km $h^{-1}$) | | | | | | |
| U15 | 11.92 ± 0.85 (384) | 11.89 ± 0.70 (384) | −0.02 [−0.13; 0.09] | −0.364 | 0.716 | −0.026 [−0.168; 0.115] |
| U16 | 12.01 ± 0.84 (312) | 12.06 ± 0.70 (312) | 0.05 [−0.08; 0.17] | 0.767 | 0.443 | 0.061 [−0.096; 0.218] |
| U17 | 12.15 ± 0.88 (249) | 12.20 ± 0.71 (249) | 0.05 [−0.09; 0.20] | 0.729 | 0.466 | 0.065 [−0.110; 0.241] |
| U18 | 12.22 ± 0.72 (119) | 12.23 ± 0.69 (119) | 0.00 [−0.17; 0.18] | 0.042 | 0.966 | 0.005 [−0.224; 0.229] |

TABLE 6 Descriptive, M ± SD (n), and inferential analyses for the factor "power and flexibility".

| | 2002 to 2005 | 2012 to 2015 | Mean difference [95% CI] | *t*-statistic | *p* | Cohen's *d* [95% CI] |
|---|---|---|---|---|---|---|
| Countermovement jump (cm) | | | | | | |
| U13 | 26.7 ± 5.2 (587) | 27.3 ± 4.9 (587) | 0.6 [0.0; 1,2] | 2.019 | 0.044 | 0.118 [0.003; 0.232] |
| U14 | 29.1 ± 5.8 (572) | 29.6 ± 5.1 (572) | 0.5 [−0.1; 1.1] | 1.569 | 0.117 | 0.093 [−0.023; 0.209] |
| U15 | 33.9 ± 5.6 (475) | 34.2 ± 5.5 (475) | 0.2 [−0.5; 1.0] | 0.689 | 0.491 | 0.045 [−0.083; 0.172] |
| U16 | 37.0 ± 5.4 (325) | 36.8 ± 6.5 (325) | −0.2 [−1.1; 0.6] | −0.479 | 0.632 | −0.038 [−0.191; 0.116] |
| U17 | 38.7 ± 5.7 (262) | 38.0 ± 5.1 (262) | −0.7 [−1.6; 0.2] | −1.499 | 0.134 | −0.131 [−0.302; 0.040] |
| U18 | 39.5 ± 5.2 (129) | 39.0 ± 5.3 (129) | −0.5 [−1.8; 0.8] | −0.749 | 0.455 | −0.093 [−0.338; 0.151] |
| Drop jump (coeff.) | | | | | | |
| U13 | 5.05 ± 1.80 (583) | 5.10 ± 2.06 (583) | 0.05 [−0.17; 0.27] | 0.422 | 0.673 | 0.025 [−0.090; 0.139] |
| U14 | 5.70 ± 1.89 (573) | 5.58 ± 2.16 (573) | −0.12 [−0.35; 0.11] | −1.008 | 0.314 | −0.060 [−0.175; 0.056] |
| U15 | 6.48 ± 2.27 (468) | 6.47 ± 2.00 (468) | −0.01 [−0.27; 0.25] | −0.092 | 0.927 | −0.006 [−0.134; 0.122] |
| U16 | 7.49 ± 2.21 (319) | 7.14 ± 2.49 (319) | −0.35 [−0.73; 0.02] | −1.900 | 0.058 | −0.150 [−0.306; 0.005] |
| U17 | 8.33 ± 2.21 (259) | 7.94 ± 2.44 (259) | −0.39 [−0.79; 0.01] | −1.901 | 0.058 | −0.167 [−0.340; 0.006] |
| U18 | 8.55 ± 2.85 (126) | 8.02 ± 2.36 (126) | −0.53 [−1.16; 0.10] | −1.611 | 0.109 | −0.203 [−0.451; 0.045] |
| 2 kg overhead medicine ball throw (m) | | | | | | |
| U13 | 6.0 ± 1.3 (580) | 5.7 ± 1.0 (580) | −0.3 [−0.4; −0.2] | −4.739 | <0.001 | −0.278 [−0.394; −0.163] |
| U14 | 7.1 ± 1.6 (567) | 6.6 ± 1.3 (567) | −0.5 [−0.7; −0.3] | −5.850 | <0.001 | −0.347 [−0.465; −0.230] |
| U15 | 8.6 ± 1.5 (470) | 8.7 ± 1.7 (470) | 0.1 [−0.1; 0.3] | 0.757 | 0.449 | 0.049 [−0.078; 0.177] |
| U16 | 9.9 ± 1.4 (323) | 9.9 ± 1.8 (323) | −0.1 [−0.3; 0.2] | −0.524 | 0.600 | −0.041 [−0.195; 0.113] |
| U17 | 10.7 ± 1.5 (261) | 10.6 ± 1.5 (261) | −0.0 [−0.3; 0.2] | −0.350 | 0.727 | −0.031 [−0.202; 0.141] |
| U18 | 11.0 ± 1.4 (126) | 11.3 ± 1.7 (126) | 0.3 [−0.1; 0.7] | 1.544 | 0.124 | 0.194 [−0.053; 0.441] |
| Sit-and-reach (cm) | | | | | | |
| U13 | 6.4 ± 5.2 (583) | 3.7 ± 6.5 (583) | −2.8 [−3.5; −2.1] | −8.091 | <0.001 | −0.474 [−0.590; −0.357] |
| U14 | 8.1 ± 5.4 (573) | 4.9 ± 5.5 (573) | −3.2 [−3.8; −2.6] | −9.973 | <0.001 | −0.589 [−0.707; −0.471] |
| U15 | 10.0 ± 6.4 (474) | 9.0 ± 7.3 (474) | −1.0 [−1.9; −0.2] | −2.328 | 0.020 | −0.151 [−0.279; −0.024] |
| U16 | 12.8 ± 6.4 (322) | 11.0 ± 8.0 (322) | −1.8 [−2.9; −0.7] | −3.204 | 0.001 | −0.253 [−0.408; −0.097] |
| U17 | 13.5 ± 6.3 (260) | 11.2 ± 6.9 (260) | −2.4 [−3.5; −1.2] | −4.065 | <0.001 | −0.357 [−0.530; −0.183] |
| U18 | 13.4 ± 6.3 (128) | 12.1 ± 7.1 (128) | −1.3 [−2.9; 0.3] | −1.542 | 0.124 | −0.193 [−0.439; 0.053] |

the importance to take these in talent identification and long-term analyses of fitness parameters into account, particularly at YDC level. Similar effects of the decade were found for reaction time at younger age groups (U13 and U15) and for general agility as well as for change-of-direction speed at academy level.

The present analysis is based upon our data from 2019 (19) but aims to best possibly determine the effect of the decade on fitness test performance alone by taking into account for some important limitations mentioned in our previous paper. It is one main strength of our study that it draws on a comprehensive fitness test battery and on a large, longitudinal and nationwide sample. A second unique feature is that the PS matching approach was applied to reduce the bias in the estimation of the decade effect on fitness when controlling for exact age, anthropometric variables, repeated testing and academy location. Unlike traditional parametric models such as the analysis of covariance, PS matching does not rely on strict assumptions about the data (67) and is capable to simultaneously control for many covariates (68). It has further advantages over alternative approaches to achieve balance in the covariate distribution particularly when conditions or groups do not fully overlap, and there are nonlinear relationships between covariates and the outcome (39).

Nevertheless, supplementary information on training content and the amount of training hours might have been beneficial to draw more precise conclusions about whether performance improvements over time can be attributed to training induced evolutions or simply to selection modifications. In addition, even though height and body mass were included as confounders, more specific conclusions about the impact of maturity on the current results may have been achieved with knowledge of the level of maturation. For the future, adding another decade (i.e., seasons 2022 to 2025) would be of great interest to further examine the fitness evolution in elite Austrian youth soccer players. Also, assuming that a sufficient amount of data are available, the athletic development from U13 to U18 should be presented in a true longitudinal design and could be further compared over the decades. The prerequisite for this approach, however, is to maintain consistency in the tests and the test procedures throughout the years. Another limitation of the current procedure might be that all tests are performed on the same day. Nevertheless, this approach is common for field-based test batteries to balance testing economy (i.e., time efficiency) and logistical factors (i.e., player availability), provided that a sufficient amount of recovery between the tests and a standardized test protocol is ensured (69).

## 5. Conclusion

Along with the evolution of physical performance in professional soccer, elite Austrian youth soccer players have become faster over a 10-year period under statistical control for exact age, anthropometric variables, repeated testing and academy location. These progressions in speed were not only restricted to advances in linear sprint speed and change-of-direction ability but also to improvements in reaction time. Soccer training should therefore target all aspects of speed, both the physical as well as the cognitive component. Preferable training contents should include small sided games and soccer-specific drills but also consist of isolated strength, power and speed training. Cognitive components should be improved by appropriate training interventions and talent diagnostics should be upgraded by adding cognitive tests. To prepare the youth soccer players optimally for the transition to the first-team and to keep up with the ongoing progressions of the elite level game demands, reference values of fitness tests in youth soccer should be updated on a regular basis. Besides those activities to enhance players' performance, flexibility training along with other preventive strategies to avoid injuries should not be neglected in order to maintain and/or increase players' availability on the pitch.

## Data availability statement

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

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. All players and their parents or guardians sign a training agreement with the ÖFB, who, for their part, gave their permission to the scientific processing of the data.

## Author contributions

CG, EM, TS, and JB contributed conception and design of the study. CG analyzed the data, prepared tables and figures, and wrote the manuscript. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

1. Fifa. "Technical Report and Statistics: 2014 FIFA World Cup Brazil". (Zurich) (2014).

2. Uefa. "Technical Report: UEFA Euro 2020". (Nyon) (2021).

3. Fifa. "Technical Report: FIFA U-20 World Cup Poland 2019". (Zurich) (2019).

4. Gonzalez-Rodenas J, Aranda-Malaves R, Tudela-Desantes A, Nieto F, Uso F, Aranda R. Playing tactics, contextual variables and offensive effectiveness in English premier league soccer matches. A multilevel analysis. *PLoS One*. (2020) 15: e0226978. doi: 10.1371/journal.pone.022697

5. Tenga A, Sigmundstad E. Characteristics of goal-scoring possessions in open play: comparing the top, in-between and bottom teams from professional soccer league. *Int J Perf Analy in Sport*. (2011) 11:545–52. doi: 10.1080/24748668.2011.11868572

6. Wright C, Atkins S, Polman R, Jones B, Sargeson L. Factors associated with Goals and Goal Scoring Opportunities in Professional Soccer. *Int J Perfor Analy in Sport*. (2011) 11: 438–49.

7. Hewitt A, Greenham G, Norton K. Game style in soccer: what is it and can we quantify it? *Int J Perfor Analy in Sport*. (2016) 16:355–72. doi: 10.1080/24748668.2016.11868892

8. Sarmento H, Anguera MT, Pereira A, Araujo D. Talent identification and development in male football: a systematic review. *Sports Med*. (2018) 48:907–31. doi: 10.1007/s40279-017-0851-7

9. Bush M, Barnes C, Archer DT, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English premier league. *Hum Mov Sci*. (2015) 39:1–11. doi: 10.1016/j.humov.2014.10.003

10. Wallace JL, Norton KI. Evolution of world cup soccer final games 1966-2010: game structure, speed and play patterns. *J Sci Med Sport*. (2014) 17:223–8. doi: 10.1016/j.jsams.2013.03.016

11. Barnes C, Archer DT, Hogg B, Bush M, Bradley PS. The evolution of physical and technical performance parameters in the English premier league. *Int J Sports Med*. (2014) 35:1095–100. doi: 10.1055/s-0034-1375695

12. Zhou C, Gomez MA, Lorenzo A. The evolution of physical and technical performance parameters in the Chinese soccer super league. *Biol Sport*. (2020) 37:139–45. doi: 10.5114/biolsport.2020.93039

13. Lago-Penas C, Lorenzo-Martinez M, Lopez-Del Campo R, Resta R, Rey E. Evolution of physical and technical parameters in the spanish LaLiga 2012-2019. *Sci Med Footb*. (2022) 7:1–6. doi: 10.1080/24733938.2022.2049980

14. Nevill AM, Okojie DI, Smith J, O'donoghue PG, Webb T. Are professional footballers becoming lighter and more ectomorphic? Implications for talent identification and development. *Int J Sports Sci Coach*. (2019) 14:329–35. doi: 10.1177/1747954119837710

15. Haugen TA, Tonnessen E, Seiler S. Anaerobic performance testing of professional soccer players 1995-2010. *Int J Sports Physiol Perform*. (2013) 8:148–56. doi: 10.1123/ijspp.8.2.148

16. Elferink-Gemser MT, Huijgen BC, Coelho-E-Silva M, Lemmink KA, Visscher C. The changing characteristics of talented soccer players – a decade of work in Groningen. *J Sports Sci*. (2012) 30:1581–91. doi: 10.1080/02640414.2012.725854

17. Tonnessen E, Hem E, Leirstein S, Haugen T, Seiler S. Maximal aerobic power characteristics of male professional soccer players, 1989-2012. *Int J Sports Physiol Perform*. (2013) 8:323–9. doi: 10.1123/ijspp.8.3.323

18. Carling C, Le Gall F, Malina RM. Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. *J Sports Sci*. (2012) 30:1683–93. doi: 10.1080/02640414.2011.637950

19. Gonaus C, Birklbauer J, Lindinger SJ, Stöggl TL, Müller E. Changes over a decade in anthropometry and fitness of elite Austrian youth soccer players. *Front Physiol*. (2019) 10:333. doi: 10.3389/fphys.2019.00333

20. Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J. Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *Eur J Appl Physiol*. (2004) 91:555–62. doi: 10.1007/s00421-003-0995-z

21. Gil SM, Badiola A, Bidaurrazaga-Letona I, Zabala-Lili J, Gravina L, Santos-Concejero J, et al. Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *J Sports Sci*. (2014) 32:479–86. doi: 10.1080/02640414.2013.832355

22. Bidaurrazaga-Letona I, Lekue JA, Amado M, Gil SM. Progression in youth soccer: selection and identification in youth soccer players aged 13-15 years. *J Strength Cond Res*. (2019) 33:2548–58. doi: 10.1519/JSC.0000000000001924

23. Patel R, Nevill A, Smith T, Cloak R, Wyon M. The influence of birth quartile, maturation, anthropometry and physical performances on player retention: observations from an elite football academy. *Int J Sports Sci Coach*. (2020) 15:121–34. doi: 10.1177/1747954120906507

24. Parr J, Winwood K, Hodson-Tole E, Deconinck FJA, Hill JP, Teunissen JW, et al. The main and interactive effects of biological maturity and relative age on physical performance in elite youth soccer players. *J Sports Med*. (2020):1–11. doi: 10.1155/2020/1957636

25. Gonaus C, Müller E. "Test-retest reliability of a field-based fitness test battery used in Austrian youth soccer". In: Balagué N, Torrents C, Vilanova A, Cadefau J, Tarragó R, Tsolakidis E, editors. *Book of abstracts of the 18th annual congress of the European college of sport science in Barcelona*. Cologne: European College of Sport Science (2013). p. 146.

26. Paul DJ, Nassis GP. Physical fitness testing in youth soccer: issues and considerations regarding reliability, validity and sensitivity. *Pediatr Exerc Sci*. (2015) 27:301–13. doi: 10.1123/pes.2014-0085

27. Stratton G, Reilly T, Williams AM, Richardson D. *Youth soccer: From science to performance*. London: Routledge (2004).

28. Unnithan V, White J, Georgiou A, Iga J, Drust B. Talent identification in youth soccer. *J Sports Sci*. (2012) 30:1719–26. doi: 10.1080/02640414.2012.731515

29. Gonaus C, Müller E. Using physiological data to predict future career progression in 14- to 17-year-old Austrian soccer academy players. *J Sports Sci*. (2012) 30:1673–82. doi: 10.1080/02640414.2012.713980

30. Drust B, Waterhouse J, Atkinson G, Edwards B, Reilly T. Circadian rhythms in sports performance—an update. *Chronobiol Int*. (2005) 22:21–44. doi: 10.1081/CBI-200041039

31. Svensson M, Drust B. Testing soccer players. *J Sports Sci*. (2005) 23:601–18. doi: 10.1080/02640410400021294

32. Harman E. "Principles of test selection and administration,". In: Baechle TR, Earle RW, editors. *Essentials of strength training and conditioning*. 3rd ed Champaign, IL: Human kinetics (2008). p. 237–47.

33. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. (2009) 41:3–13. doi: 10.1249/MSS.0b013e31818cb278

34. Thoemmes F. Propensity score matching in SPSS. (2012). Available: https://arxiv.org/abs/1201.6385 (Accessed 30.07.2019).

35. Stuart EA. Matching methods for causal inference: a review and a look forward. *Stat Sci*. (2010) 25:1–21. doi: 10.1214/09-STS313

36. Lunt M. Selecting an appropriate caliper can be essential for achieving good balance with propensity score matching. *Am J Epidemiol*. (2014) 179:226–35. doi: 10.1093/aje/kwt212

37. Rosenbaum PR, Rubin DB. Constructing a control-group using multivariate matched sampling methods that incorporate the propensity score. *Am Stat*. (1985) 39:33–8. doi: 10.2307/2683903

38. Caliendo M, Kopeinig S. Some practical guidance for the implementation of propensity score matching. *J Econ Surv*. (2008) 22:31–72. doi: 10.1111/j.1467-6419.2007.00527.x

39. West SG, Cham H, Thoemmes F, Renneberg B, Schulze J, Weiler M. Propensity scores as a basis for equating groups: basic principles and application in clinical treatment outcome research. *J Consult Clin Psychol*. (2014) 82:906–19. doi: 10.1037/a0036387

40. Schafer JL, Kang J. Average causal effects from nonrandomized studies: a practical guide and simulated example. *Psychol Methods*. (2008) 13:279–313. doi: 10.1037/a0014268

41. Austin PC. A comparison of 12 algorithms for matching on the propensity score. *Stat Med*. (2014) 33:1057–69. doi: 10.1002/sim.6004

42. Enders CK. *Applied missing data analysis*. New York: Guilford Press (2010).

43. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for *t*-tests and ANOVAs. *Front Psychol*. (2013) 4:863. doi: 10.3389/fpsyg.2013.00863

44. Cohen J. A power primer. *Psychol Bull*. (1992) 112:155–9. doi: 10.1037/0033-2909.112.1.155

45. Nassis GP, Massey A, Jacobsen P, Brito J, Randers MB, Castagna C, et al. Elite football of 2030 will not be the same as that of 2020: preparing players, coaches, and support staff for the evolution. *Scand J Med Sci Sports*. (2020) 30:962–4. doi: 10.1111/sms.13681

46. Reilly T. Training specificity for soccer. *Int J Appl Sports Sci*. (2005) 17:17–25.

47. Bujalance-Moreno P, Latorre-Roman PA, Garcia-Pinillos F. A systematic review on small-sided games in football players: acute and chronic adaptations. *J Sports Sci*. (2019) 37:921–49. doi: 10.1080/02640414.2018.1535821

48. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. *J Sports Sci*. (2006) 24:919–32. doi: 10.1080/02640410500457109

49. Chaouachi A, Chtara M, Hammami R, Chtara H, Turki O, Castagna C. Multidirectional sprints and small-sided games training effect on agility and change of direction abilities in youth soccer. *J Strength Cond Res*. (2014) 28:3121–7. doi: 10.1519/JSC.0000000000000505

50. Querido SM, Clemente FM. Analyzing the effects of combined small-sided games and strength and power training on the fitness status of under-19 elite football players. *J Sports Med Phys Fitness*. (2020) 60:1–10. doi: 10.23736/S0022-4707.19.09818-9

51. Douchet T, Paizis C, Carling C, Cometti C, Babault N. Typical weekly physical periodization in French academy soccer teams: a survey. *Biol Sport*. (2023) 40:731–40. doi: 10.5114/biolsport.2023.119988

52. Dolci F, Hart NH, Kilding AE, Chivers P, Piggott B, Spiteri T. Physical and energetic demand of soccer: a brief review. *Strength Cond J*. (2020) 42:70–7. doi: 10.1519/SSC.0000000000000533

53. Murr D, Raabe J, Höner O. The prognostic value of physiological and physical characteristics in youth soccer: a systematic review. *Eur J Sport Sci*. (2018) 18:62–74. doi: 10.1080/17461391.2017.1386719

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

55. Huijgen BC, Leemhuis S, Kok NM, Verburgh L, Oosterlaan J, Elferink-Gemser MT, et al. Cognitive functions in elite and sub-elite youth soccer players aged 13 to 17 years. *PLoS One*. (2015) 10:e0144580. doi: 10.1371/journal.pone.014458

56. Goncalves E, Noce F, Barbosa MaM, Figueiredo AJ, Teoldo I. Maturation, signal detection, and tactical behavior of young soccer players in the game context. *Sci Med Footb*. (2021) 5:272–9. doi: 10.1080/24733938.2020.1851043

57. Henderson G, Barnes CA, Portas MD. Factors associated with increased propensity for hamstring injury in English premier league soccer players. *J Sci Med Sport*. (2010) 13:397–402. doi: 10.1016/j.jsams.2009.08.003

58. Garcia-Pinillos F, Ruiz-Ariza A, Moreno Del Castillo R, Latorre-Roman PA. Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. *J Sports Sci*. (2015) 33:1293–7. doi: 10.1080/02640414.2015.1022577

59. Perez-Gomez J, Adsuar JC, Alcaraz PE, Carlos-Vivas J. Physical exercises for preventing injuries among adult male football players: a systematic review. *J Sport Health Sci*. (2022) 11:115–22. doi: 10.1016/j.jshs.2020.11.003

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

61. Johnson A, Farooq A, Whiteley R. Skeletal maturation status is more strongly associated with academy selection than birth quarter. *Sci Med Footb*. (2017) 1:157–63. doi: 10.1080/24733938.2017.1283434

62. Vandendriessche JB, Vaeyens R, Vandorpe B, Lenoir M, Lefevre J, Philippaerts RM. Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15-16 years). *J Sports Sci*. (2012) 30:1695–703. doi: 10.1080/02640414.2011.652654

63. Towlson C, Macmaster C, Parr J, Cumming S. One of these things is not like the other: time to differentiate between relative age and biological maturity selection biases in soccer? *Sci Med Footb*. (2022) 6:273–6. doi: 10.1080/24733938.2021.1946133

64. Sturmer T, Joshi M, Glynn RJ, Avorn J, Rothman KJ, Schneeweiss S. A review of the application of propensity score methods yielded increasing use, advantages in specific settings, but not substantially different estimates compared with conventional multivariable methods. *J Clin Epidemiol*. (2006) 59:437–47. doi: 10.1016/j.jclinepi.2005.07.004

65. Thoemmes FJ, Kim ES. A systematic review of propensity score methods in the social sciences. *Multivariate Behav Res*. (2011) 46:90–118. doi: 10.1080/00273171.2011.540475

66. Austin PC. An Introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behav Res*. (2011) 46:399–424. doi: 10.1080/00273171.2011.568786

67. Beal SJ, Kupzyk KA. An Introduction to propensity scores: what, when, and how. *J Early Adolesc*. (2014) 34:66–92. doi: 10.1177/0272431613503215

68. D'agostino RB. Propensity scores in cardiovascular research. *Circulation*. (2007) 115:2340–3. doi: 10.1161/CIRCULATIONAHA.105.594952

69. Turner A, Walker S, Stembridge M, Coneyworth P, Reed G, Birdsey L, et al. A testing battery for the assessment of fitness in soccer players. *Strength Cond J*. (2011) 33:29–39. doi: 10.1519/SSC.0b013e31822fc80a

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# Reliability and sensitivity to change of post-match physical performance measures in elite youth soccer players

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**Introduction:** To effectively monitor post-match changes in physical performance, valid, reliable and practical measures which are sensitive to change are required. This study aimed to quantify test-retest reliability and sensitivity to change of a range of physical performance measures recorded during an isometric posterior chain (IPC) lower-limb muscle test and a countermovement jump (CMJ) test.
**Methods:** Eighteen Italian Serie A academy soccer players performed three IPC repetitions per limb and five CMJ trials in 4 testing sessions. Test-retest reliability was evaluated between two testing sessions seven days apart using typical error of measurement, coefficient of variation and intraclass correlation coefficient. Sensitivity to change was assessed on two additional testing sessions performed before and immediately after a soccer match through Hedges' g effect size (g) and comparisons to typical error.
**Results:** Absolute reliability (coefficient of variations) ranged from 1.5 to 8.8%. IPC and CMJ measures demonstrated *moderate* to *excellent* relative reliability (intraclass correlation coefficients ranged from 0.70 to 0.98). A wide range of physical performance measures showed significant alterations post-match ($p < 0.05$; *g*: *small* to *moderate*). IPC peak force and torque, CMJ reactive strength index modified, CMJ eccentric forces (mean breaking force, mean deceleration force, peak force, force at zero velocity) and CMJ mean power measures had post-match changes greater than their typical variation, demonstrating acceptable sensitivity in detecting performance changes at post-match.
**Discussion:** IPC peak force and torque, CMJ reactive strength index modified, CMJ eccentric phase forces and CMJ mean power were found to be both reliable and sensitive to change, and thus may be appropriate for monitoring post-match neuromuscular performance in youth soccer population.

KEYWORDS
monitoring, neuromuscular fatigue, recovery, reliability, responsiveness, football

## 1. Introduction

Soccer match-play represents the most demanding stimulus of the competitive microcycle (1, 2) and has been shown to induce metabolic and mechanical fatigue acutely and in the days following the match in elite senior and youth soccer players (3–6). Nowadays, elite youth soccer players can be exposed to demanding periods of training and competition with limited between-match recovery time (7). The collective stresses

accumulated during the competitive season may lead players to a fatigued status, which may impact their preparedness for subsequent competition and increase the risk of non-functional overreaching, injury, and illness (8). This scenario has prompted a greater interest in monitoring players' post-match fatigue to inform training loads and recovery strategies within the weekly microcycle (9). Fatigue can be defined as a decline in an objective measure of performance over a discrete period (e.g., a decrease in force and power output), and as an increased perception of effort that regulates the integrity of an individual (10). A myriad of field-based physical performance tests is used to assess individual responses following training or competition (11), including isometric tests (e.g., squat, mid-thigh pull, posterior chain) and dynamic measures such as vertical jumps (12). Despite the widespread use of these player monitoring tools, evidence regarding the suitability of a comprehensive range of physical performance measures for monitoring post-match responses in a youth soccer population is limited.

A suitable measure used for effectively monitoring post-match response should possess high reproducibility between repeated tests performed under similar conditions (i.e., reliability) (13, 14) and should be capable of detecting changes induced by training or a match (i.e., sensitivity to change or responsiveness) (9). The reliability of a test refers to the degree of consistency between repeated tests within a practically relevant timeframe (13, 14), while sensitivity to change refers to the ability of a measure to change over a particular timeframe (15). Quantifying both test-retest reliability and sensitivity to change of post-match neuromuscular fatigue measures has been recommended to better interpret individual responses in high-performance sports (16, 17). Additionally, considering the challenges of team-sport settings, tests used for post-match response monitoring should be selected according to their relevance to performance and feasibility within the environment (18). Although numerous studies have reported the reliability of physical performance measures in youth soccer players including vertical jumps and isometric tests (19–21), less research has focused on examining their sensitivity to change following match-play (22).

The countermovement jump (CMJ) test is widely used in high-performance sports to indirectly monitor changes in neuromuscular fatigue and subsequent recovery in both team and individual sports (23, 24). Previous research in youth soccer has mainly investigated the reliability of outcome measures such as jump height (CVs: 4.3%–4.8%; ICCs: 0.83–0.88) (19, 20). Despite possessing acceptable levels of reliability, jump height has been demonstrated to have limited sensitivity to change in training loads in youth and senior soccer players (25, 26). Following a youth academy match play, decrements in CMJ height were observed immediately post and at +24 h, with a tendency towards recovery at +48 h post-match (6). Considering the metabolic, mechanical and neural factors associated with neuromuscular fatigue (10), measuring ground reaction forces during the CMJ may offer superior insights for indirectly detect neuromuscular fatigue (27). Previous research has examined the reliability and sensitivity to change of various CMJ measures in other sports, demonstrating their suitability for ongoing monitoring (16, 22, 28, 29). In the context of youth soccer, additional research is required to identify reliable CMJ measures capable of detecting neuromuscular fatigue changes.

In team sports, physical performance monitoring also includes isometric tests, used in combination with vertical jumps (12) or as an alternative evaluation (30). Predominantly due to the elevated high-speed running demands (31) and the role of fatigue on hamstring strain injuries in soccer (32), hamstring assessment protocols were introduced as a tool to quantify muscle-specific neuromuscular fatigue during the competitive season. Soccer match results in substantial muscle function impairments until 48–72 h post-match with alterations in muscle contractile properties and central motor output (3). Larger and longer magnitudes of alterations have been observed for knee flexors compared to knee extensors, suggesting the importance of monitoring hamstring function at post-match (33). An isometric posterior chain (IPC) test has been proposed to measure the peak forces generated by the posterior chain musculature at 30° and 90° knee flexion in professional soccer players (34). IPC peak forces have been demonstrated to be reliable (CVs: 4%–6%; ICCs: 0.82–0.95) (34, 35) and sensitive to change following a competitive match-play (relative post-match changes from −20% to −10%) (34, 36). Despite its applicability, peak force does not account for individual differences in limb length and research examining the peak torque generated from the maximal voluntary contraction during the IPC is lacking. Therefore, it is important to demonstrate the reliability and sensitivity of IPC peak force and torque in the specific population to inform practitioners of the potential applications of this testing protocol.

This study extends previous research by quantifying the measurement characteristics of a range of physical performance measures used for monitoring post-match responses in elite youth soccer. Monitoring post-match neuromuscular fatigue using reliable and sensitive measures could potentially inform training prescription and recovery strategies at the individual level within the current or upcoming microcycle to ultimately optimize players' preparedness and development. Therefore, the aim of this study was to (1) quantify the reliability and (2) examine the sensitivity of a range of different physical performance measures from the IPC lower-limb muscle test and the CMJ test in a group of elite youth soccer players.

## 2. Materials and methods

### 2.1. Subjects

Eighteen elite youth soccer players (mean ± SD, age: 16.7 ± 0.3 years, height: 177.5 cm ± 5.9 cm, body mass: 70.4 ± 4.4 kg, percentage adult height: 99.5 ± 0.5%, maturity offset: 2.6 ± 0.5 years) from the under-17 squad of a professional soccer academy in the Italian Serie A participated in this study. All players were free from injury and illness and completed on average 10 h of training (i.e., 5 training sessions) per week, plus a competitive match. Data collection was part of the club's monitoring system and written informed consent was provided by parents or legal

guardians. Ethics approval for the study was provided by the University Research Ethics Committee (22/SPS/006) and was conducted in accordance with the Declaration of Helsinki.

## 2.2. Design

The study was completed during the competitive season and consisted of a test-retest reliability and sensitivity to change assessment of physical performance measures commonly used for post-match monitoring (**Figure 1**). The IPC and the CMJ test were used for all test sessions. All players received a minimum of two familiarization sessions in the weeks before the experimental trials. Reliability assessment consisted of two testing sessions spaced 7 days apart using a test-retest design. Test-retest reliability sessions were conducted following a 72 hour rest period during which players refrained from participating in training and vigorous activity Sensitivity to change was evaluated using an intra-club friendly match ($2 \times 40$ min, $105\ m \times 68\ m$, artificial turf) as the intervention. Match demands were quantified using global navigation satellite systems (Apex Pro Series, 10 Hz GNSS, STATSports, Northern Ireland) and heart rate (HR) sensors (Polar H10, Polar, Finland). The average match demands were: total distance covered: 10,091 m ± 834 m; distance covered >20 km/h: 720 m ± 203 m; distance covered >25 km/h: 159 m ± 91 m; number of accelerations >3 m/s$^2$: 60 ± 14; number of decelerations <−3 m/s$^2$: 69 ± 15; time spent >85% HRmax: 29:48 ± 16:27 min; and time spent >90% HRmax: 9:13 ± 6:20 min. Each testing session was conducted at the same time of the day (i.e., early afternoon) to limit the influence of circadian variation and took place following a standardized 5-minute warm-up, except for the session performed immediately after the match. Testing sessions for sensitivity were performed pre- (i.e., 1 h and half before the commencement of the match) and immediately post-match (i.e., within 30 min of completing the match), including only the players who completed the full 80-minute duration. Players were instructed to maintain their normal dietary intake throughout the experimental period. Eighteen players completed the tests for reliability, while thirteen players completed the entire match and performed the tests for sensitivity.

## 2.3. Methodology

The IPC and the CMJ test were conducted using a force platform (ForceDecks Dual Force Plate System FD lite, VALD Performance, Australia). ForceDecks software was used to analyze and calculate the selected physical performance measures. The sampling rate of the force plate was 1,000 Hz.

### 2.3.1. Isometric posterior chain (IPC) lower-limb muscle test

Players lay in a supine position with their knee at 90° (IPC-90°) or 30° (IPC-30°) of flexion, with their calcaneus on the center of the force platform and the non-test leg extended alongside a box at an appropriate height for each participant (i.e., lower shank to be parallel to the floor) (32). Players performed a 3s maximal voluntary contraction by driving their heel down as hard as possible into the platform. The tester ensured a correct position of both legs and pressure was applied to the contralateral hip to control participant posture (i.e., keeping the buttocks, hips and head on the floor). Players were required to repeat trials if their hips raised off the ground. Three trials on each limb were executed with 30s rest between trials for both IPC-90° and IPC-30° lower-limb muscle tests. Peak force was quantified for each trial. Moment arm length was measured from the joint axis of rotation to the point of application of the force and peak torque was calculated by multiplying the peak force by the length of the moment arm. For both the dominant and non-dominant leg, the three-trial average of peak force and peak torque were used for the subsequent statistical analysis.

### 2.3.2. Countermovement jump (CMJ) test

Players performed five CMJ trials with 20s rest between trials. Before the commencement of each jump, players were advised to stand upright, with their arms akimbo and their feet hip-shoulder width apart. Once the starting position was adopted, players remained as still as possible for at least 3s before the start of the trial for the collection of the player's body weight. During the countermovement players were instructed to rapidly squat to their preferred depth and immediately jump as fast and as high as possible, with no knee or hip flexion during the flight phase, maintaining the

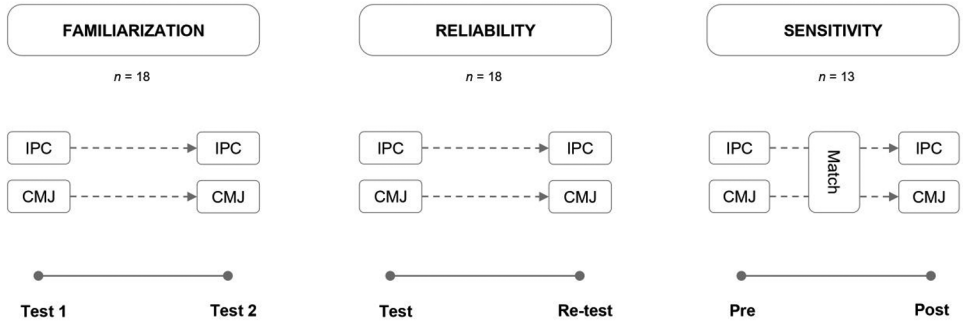


FIGURE 1
A schematic representation of the study design. Following the familiarization sessions, reliability was evaluated using a test-re-test design seven days apart. Sensitivity to change was evaluated following a match with testing sessions performed before and immediately after. IPC: isometric posterior-chain; CMJ: countermovement jump.

hands on the hips. Finally, players were encouraged to "absorb" the landing by flexing at the hips, knees, and ankles after impacting the force platform (37). The average of the three best trials was used for the subsequent statistical analyses (38) for the following CMJ measures: jump height (JH), contraction time (CT), reactive strength index modified (RSImod), concentric duration (ConcDur), concentric peak force (ConcPF), concentric peak velocity (ConcPV), concentric mean power (ConcMP), peak power (PP), eccentric duration (EccDur), eccentric braking phase duration (EccBrakPhDur), eccentric deceleration phase duration (EccDecPhDur), eccentric mean braking force (EccMBrakF), eccentric mean deceleration force (EccMDecF), eccentric peak force (EccPF), force at zero velocity (F@0 V) and eccentric mean power (EccMP) (**Supplementary Material**). These measures were selected to describe both outcome and movement strategy measures (28) and agree with previous works completed in other high-performance environments (16, 17).

## 2.4. Statistical analysis

Descriptive data are reported as mean ± standard deviation (SD). The assumption of normality was assessed using a Shapiro-Wilk test. Differences between the two reliability test sessions and between pre- and post-match for sensitivity were tested for each measure using a paired *t*-test with alpha ≤0.05. For the reliability analysis, the typical error (TE) of measurement and the coefficient of variation (CV) were reported as measures of absolute reliability, while the intraclass correlation coefficient 3,1 (ICC; 2-way mixed-effects) with 95% confidence intervals was reported as a measure of relative reliability (13, 39). ICCs were interpreted in line with the lower 95% CI boundary based on previous recommendations: *excellent* (>0.90), *good* (0.75–0.90), *moderate* (0.50–0.75) and *poor* (<0.50) (40). For the sensitivity to change analysis, the magnitude of differences was assessed using Hedges' *g* effect size (*g*) with 95% CI. Criteria for effect size statistics were interpreted as follows: *trivial* (<0.2), *small* (0.2–0.6), *moderate* (0.6-1.2), *large* (1.2–2.0) and *very large* (>2.0) (41). To determine the ability of each measure in detecting relevant post-match variations, changes were reported and assessed against TE values. If post-match changes were greater than 1.5 times the TE in the test, changes were deemed as sensitive to change (i.e., responsive) (13). The statistical analysis was performed using SPSS statistical software (IBM SPSS version 26, Chicago, IL, USA).

# 3. Results

## 3.1. Reliability of physical performance measures

Reliability statistics are shown in **Table 1**. Absolute reliability (CVs) ranged from 1.5 to 8.8%. Relative reliability (ICCs) ranged

TABLE 1 Reliability statistics of physical performance measures from the isometric posterior chain (IPC) and the countermovement jump (CMJ) test in elite youth soccer players.

| | Test 1 Mean (SD) | Test 2 Mean (SD) | *t* test (p) | Change in mean (95% CI) | TE | CV | ICC (95% CI) |
|---|---|---|---|---|---|---|---|
| Isometric posterior chain test | | | | | | | |
| Peak Force (N)—Dominant leg at 90° | 317.2 (54.5) | 319.9 (57.1) | 0.406 | −2.7 (−9.6 to 4.1) | 9.7 | 3.0 | 0.97 (0.92 to 0.99) |
| Peak Force (N)—Non-dominant leg at 90° | 289.9 (49.2) | 296.5 (47.2) | 0.123 | −6.6 (−15.3 to 2.0) | 12.3 | 4.2 | 0.93 (0.84 to 0.97) |
| Peak Torque (Nm)—Dominant leg at 90° | 128.3 (23.3) | 129.6 (24.1) | 0.307 | −1.3 (−3.9 to 1.3) | 3.7 | 2.9 | 0.98 (0.93 to 0.99) |
| Peak Torque (Nm)—Non-dominant leg at 90° | 117.4 (21.7) | 120.4 (20.6) | 0.081 | −3.0 (−6.3 to 0.4) | 4.8 | 4.0 | 0.95 (0.89 to 0.98) |
| Peak Force (N)—Dominant leg at 30° | 299.2 (49.1) | 299.4 (45.8) | 0.966 | −0.2 (−9.8 to 9.4) | 13.6 | 4.6 | 0.92 (0.79 to 0.97) |
| Peak Force (N)—Non-dominant leg at 30° | 268.9 (47.2) | 275.1 (45.6) | 0.174 | −6.2 (−15.3 to 3.0) | 13.0 | 4.8 | 0.92 (0.80 to 0.97) |
| Peak Torque (Nm)—Dominant leg at 30° | 121 (21.1) | 121.1 (19.6) | 0.965 | −0.1 (−4.0 to 3.8) | 5.6 | 4.6 | 0.93 (0.81 to 0.97) |
| Peak Torque (Nm)—Non-dominant leg at 30° | 108.8 (19.7) | 111.2 (20.1) | 0.155 | −2.7 (−6.4 to 1.1) | 5.4 | 4.9 | 0.93 (0.82 to 0.97) |
| Countermovement jump test | | | | | | | |
| Jump Height (cm) | 37.0 (3.9) | 36.8 (3.7) | 0.437 | 0.2 (−0.4 to 0.9) | 1.0 | 2.6 | 0.93 (0.83 to 0.97) |
| Contraction Time (ms) | 713.6 (73.1) | 719.6 (84.6) | 0.570 | −6.0 (−27.7 to 15.8) | 30.9 | 4.3 | 0.85 (0.64 to 0.94) |
| RSImodified (m/s) | 0.53 (0.08) | 0.52 (0.09) | 0.296 | 0.01 (−0.01 to 0.03) | 0.02 | 4.0 | 0.93 (0.83 to 0.97) |
| Concentric Duration (ms) | 260.9 (28.7) | 262.4 (34.7) | 0.702 | −1.5 (−9.9 to 6.8) | 11.9 | 4.5 | 0.86 (0.66 to 0.95) |
| Concentric Peak Force (N) | 1,757.4 (204.1) | 1,749.7 (238.5) | 0.693 | 7.7 (−32.8 to 48.2) | 57.6 | 3.3 | 0.93 (0.83 to 0.97) |
| Concentric Peak Velocity (m/s) | 2.77 (0.13) | 2.77 (0.14) | 0.578 | 0.01 (−0.02 to 0.04) | 0.04 | 1.5 | 0.91 (0.77 to 0.96) |
| Concentric Mean Power (W) | 2,087.5 (350.0) | 2,083.6 (398.0) | 0.847 | 3.8 (−37.4 to 45.1) | 58.6 | 2.8 | 0.97 (0.94 to 0.99) |
| Peak Power (W) | 3,702.6 (651.1) | 3,723.0 (682.8) | 0.524 | −20.4 (−86.5 to 45.7) | 94.0 | 2.5 | 0.98 (0.95 to 0.99) |
| Eccentric Duration (ms) | 455.2 (48.6) | 457.1 (54.8) | 0.764 | −2.0 (−15.6 to 11.6) | 19.3 | 4.2 | 0.86 (0.67 to 0.95) |
| Eccentric Braking Phase Duration (s) | 0.28 (0.44) | 0.28 (0.43) | 0.875 | 0.00 (−0.01 to 0.02) | 0.02 | 7.6 | 0.77 (0.51 to 0.91) |
| Eccentric Deceleration Phase Duration (s) | 0.16 (0.27) | 0.16 (0.28) | 0.584 | 0.00 (−0.01 to 0.01) | 0.01 | 8.8 | 0.70 (0.37 to 0.88) |
| Eccentric Mean Braking Force (N) | 896.8 (91.5) | 900.5 (95.2) | 0.614 | −3.7 (−19.0 to 11.6) | 21.8 | 2.4 | 0.95 (0.86 to 0.98) |
| Eccentric Mean Deceleration Force (N) | 1,348.5 (142.8) | 1,335.5 (167.1) | 0.440 | 13.0 (−21.7 to 47.7) | 49.4 | 3.7 | 0.90 (0.75 to 0.96) |
| Eccentric Peak Force (N) | 1,739.9 (192.6) | 1,737.2 (230.5) | 0.926 | −2.7 (−42.9 to 48.2) | 64.8 | 3.7 | 0.91 (0.77 to 0.96) |
| Force at Zero Velocity (N) | 1,729.5 (194.6) | 1,725.5 (236.4) | 0.903 | 4.0 (−42.6 to 50.6) | 66.3 | 3.8 | 0.91 (0.77 to 0.97) |
| Eccentric Mean Power (W) | 498.1 (76.6) | 498.8 (61.6) | 0.860 | −0.7 (−16.8 to 15.4) | 22.8 | 4.6 | 0.89 (0.73 to 0.96) |

CI, confidence intervals; TE, typical error of measurement; CV, coefficient of variation; ICC, intraclass correlation coefficient, RSI, reactive strength index.

from *good* to *excellent* for IPC measures (ICC ≥0.93; 95% CI: 0.79 to 0.99), whilst it ranged from *moderate* to *excellent* for the CMJ measures (ICC ≥0.85; 95% CI: 0.61 to 0.99), except for Eccentric Braking Phase Duration (EccBrakPhDur) and Eccentric Deceleration Phase Duration (EccDecPhDur) (ICC: 0.70 and 0.77; 95% CI: 0.37 to 0.88, and 0.51 to 0.91, respectively).

### 3.2. Sensitivity of physical performance measures

A wide range of IPC and CMJ measures showed significant alterations at post-match ($p < 0.05$) (**Figures 2**, **3**, **Table 2**). The magnitude of change at post-match was *moderate* (from −10.0% to−10.6%; *g*: from −0.58 to −0.53) for IPC measures, while it spanned from *trivial* to *moderate* (from −0.8 to −10.7%; *g*: from −0.78 to 0.65) for CMJ measures (**Figures 2**, **3**, **Table 2**). Eleven measures (IPC-90° PF DL, IPC-90° PF NDL, IPC-90° PT DL, IPC-90° PT NDL, RSImod, EccMBF, EccMDecF, EccPF, F@0 V, EccMP, ConcMP) displayed mean changes greater than typical variation (i.e., 1.5 times the TE) (**Figures 2**, **3**, **Table 2**). Conversely, the other nine measures (JH, CT, ConcPF, EccDur, EccBrakPhDur, EccDecPhDur, ConcDur, ConcPV, PP) displayed mean changes lower than their corresponding typical variation (**Figures 2**, **3**, **Table 2**).

## 4. Discussion

The purpose of this study was to quantify the reliability and examine the sensitivity to change of a range of physical performance measures in a group of elite youth soccer players. The main findings from this study were: (1) IPC and CMJ neuromuscular measures demonstrated a high level of absolute reliability (CVs from 1.5 to 8.8%) and *moderate* to *excellent* level of relative reliability (ICCs from 0.70 to 0.98); (2) IPC peak force and torque, CMJ RSImod, CMJ eccentric forces (EccMBF, EccMDecF, EccPF, F@0 V) and CMJ mean power measures showed significant reductions of *small* to *moderate* effect and acceptable sensitivity by displaying post-match changes greater than their typical variation (**Figures 2**, **3**); and (3) CMJ concentric phase measures and jump height showed *trivial* to *small* alterations by displaying post-match changes similar to their typical variation in elite youth soccer players (**Figures 2**, **3**). These findings suggest that IPC peak force and torque, CMJ RSImod, CMJ eccentric phase forces and CMJ mean power may be considered more suitable measures for monitoring players' post-match neuromuscular performance in elite youth soccer players.

### 4.1. Reliability of physical performance measures

IPC lower-limb muscle peak force and torque were demonstrated to be reliable for both dominant and non-dominant leg at 90° and 30° knee flexion. There is no direct comparative reliability data reporting peak torque recorded during the IPC test in youth soccer players. However, our findings are consistent with previous literature on professional soccer players which have reported better repeatability at 90° knee flexion compared to 30° knee flexion position (CV: 4.3% and 6.3%, respectively) (34). When comparing our reliability data with that of peak force from previous studies (34, 35), it appears that peak torque has greater absolute and relative reliability (CV <5%; ICC >0.90) compared to peak force. One important consideration in reporting peak torque rather than peak force data is that it accounts for individual differences in limb length (42). Practitioners may therefore consider the IPC as a reliable neuromuscular performance test for monitoring post-match response in youth soccer players.

Most of the CMJ measures from the eccentric and concentric phases demonstrated a high level of absolute and relative reliability in our sample. Previous literature in youth soccer quantified the reliability of jump height only (19, 20). Our results showed greater absolute (CV: 2.6%) and relative (ICC: 0.93) reliability for jump height. These differences may be a result of the different technologies used between studies (i.e., force platform vs. contact mat vs. optical system). Additionally, we quantified the reliability of a wide range of eccentric and concentric phase measures which may provide deeper insights related to both jump outcome and movement strategy (28). Our CVs are lower than in previous literature that used a similar methodology (28, 29), which may be due to the differences in testing protocols, environment and population. However, CVs (1.7%–11.0%) and ICCs (0.70–0.99) were similar to that of a recent study conducted with professional rugby union players which quantified the reliability of 86 CMJ measures (16). Interestingly, CMJ concentric phase and jump outcome measures (e.g., jump height and peak power) displayed better reliability statistics when compared with time-based CMJ measures, suggesting greater variability of jump strategy measures. Despite this trend, several jump strategy measures (e.g., EccDur, RSImod, F@0 V) demonstrated an acceptable level of reliability and therefore may be valuable for monitoring post-match physical performance. In this light, this study uniquely provides reliability reference data of a comprehensive range of CMJ measures within an elite youth soccer academy environment.

### 4.2. Sensitivity of physical performance measures

Determining the inclusion or exclusion of neuromuscular performance measures based on reliability alone may lead to erroneous conclusions. A novel aspect of the present study was to establish the level of reliability in conjunction with the sensitivity to change for effectively monitoring post-match neuromuscular performance in youth soccer players. The significant reductions in IPC measures at 90° dominant and non-dominant leg (−10% at post-match) suggest that soccer match play results in acute alterations of hamstring neuromuscular function in youth soccer players, in agreement with previous

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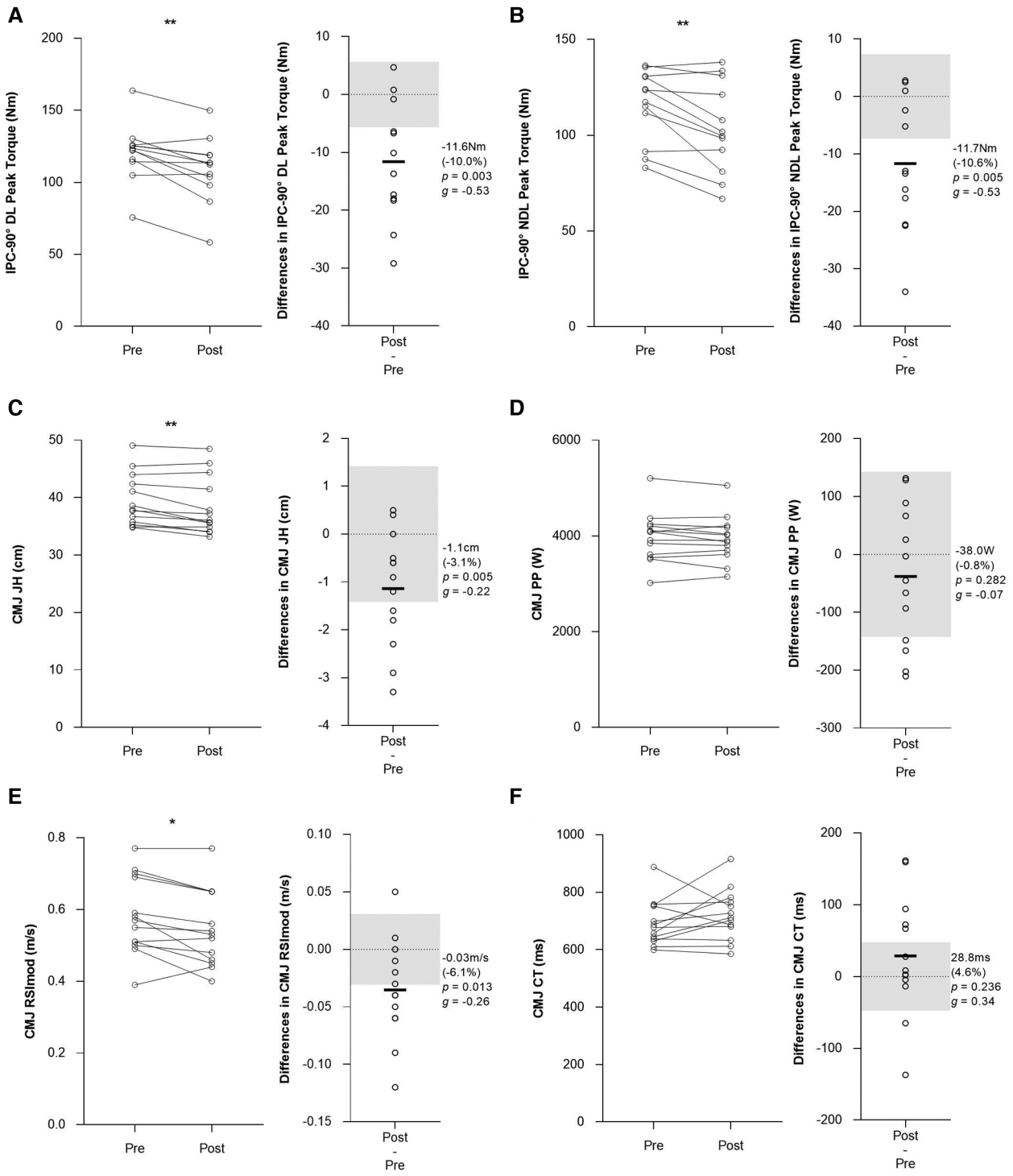


FIGURE 2
Post-match individual changes, mean difference (absolute and relative), *p*-value and Hedges' *g* effect size of physical performance measures in elite youth soccer players. (**A**) IPC-90° peak torque of dominant leg, (**B**) IPC-90° peak torque of non-dominant leg, (**C**) CMJ jump height, (**D**) CMJ peak power, (**E**) CMJ RSImodified, (**F**) CMJ contraction time. Light grey boxes represent the 1.5 times the TE of each measure to identify the players who exhibited changes greater than the typical variance in the IPC and CMJ test. * indicates a significant mean difference at post-match ($p \leq 0.05$), ** indicates a significant mean difference at post-match ($p \leq 0.01$), ** indicates a significant mean difference at post-match ($p \leq 0.001$). IPC-90° DL: isometric posterior chain 90° dominant leg; IPC-90° NDL: isometric posterior chain 90° non-dominant leg; JH: jump height; PP: peak power; RSImod: reactive strength index modified; CT: contraction time.

literature (36). However, the magnitude of post-match decline recorded in our research is smaller compared to previous studies (−15% at post-match) that assess hamstring neuromuscular function following a 90 minute competitive match (34, 43). Despite the difference in the magnitude of change, IPC peak force and torque were demonstrated to be sensitive to change by

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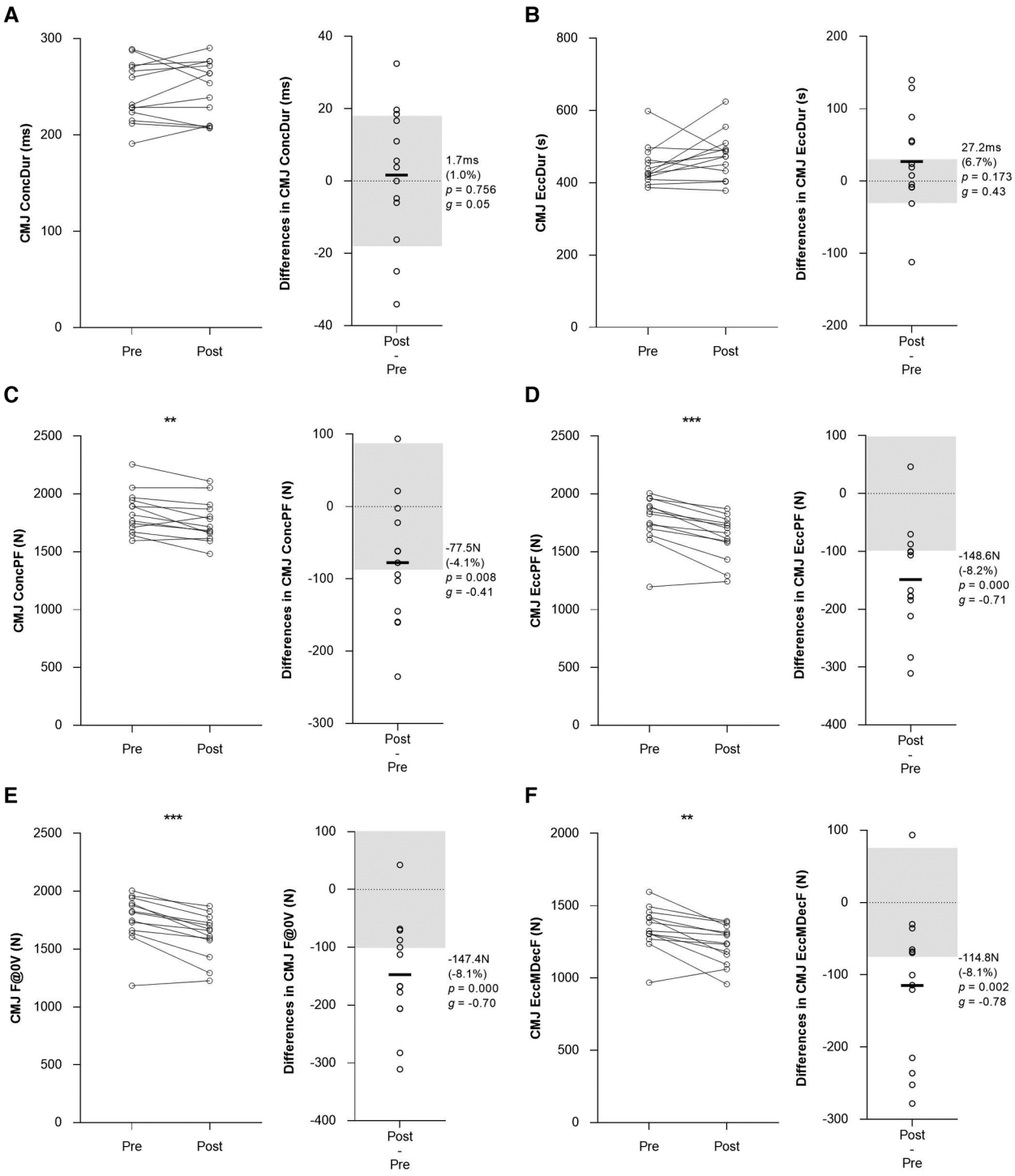


FIGURE 3
Post-match individual changes, mean difference (absolute and relative), *p*-value and Hedges' *g* effect size of physical performance measures in elite youth soccer players. (A) CMJ concentric duration, (B) CMJ eccentric duration, (C) concentric peak force, (D) eccentric peak force, (E) force at zero velocity, (F) eccentric mean deceleration force. Light grey boxes represent the 1.5 times the TE of each measure to identify the players who exhibited changes greater than the typical variance in the IPC and CMJ test. * indicates a significant mean difference at post-match ($p \leq 0.05$), ** indicates a significant mean difference at post-match ($p \leq 0.01$), ** indicates a significant mean difference at post-match ($p \leq 0.001$). ConcDur: concentric duration; EccDur: eccentric duration; ConcPF: concentric peak force; EccPF; eccentric peak force; F@0V: force at zero velocity; EccMDecF: eccentric mean deceleration force.

detecting post-match changes greater than the typical variation for both dominant and non-dominant legs. These moderate reductions in force and torque (−10% at post-match) likely reflect the high eccentric involvement of the hamstring muscles during repeated sprinting, which could alter muscle function and lead to exercise-induced muscle damage in the days following the competition

TABLE 2 Sensitivity to change of physical performance measures from the isometric posterior chain (IPC) and the countermovement jump (CMJ) test in elite youth soccer players.

| | Pre-match Mean (SD) | Post-match Mean (SD) | *t* test (*p*) | Change in mean (95% CI) | ES Hedges's *g* (95% CI) | | TE × 1.5 | Sensitivity to change |
|---|---|---|---|---|---|---|---|---|
| **Isometric posterior chain test** | | | | | | | | |
| Peak Force (N)—Dominant leg at 90° | 302.2 (46.9) | 272.6 (52.0) | 0.002** | −29.6 (−46.2 to −12.9) | −0.58 (−1.44 to 0.29) | M | 14.5 | Yes |
| Peak Force (N)—Non-dominant leg at 90° | 289.1 (42.6) | 259.5 (54.0) | 0.005** | −29.6 (−47.9 to −11.2) | −0.59 (−1.45 to 0.28 | M | 18.4 | Yes |
| Peak Torque (Nm)—Dominant leg at 90° | 120.7 (19.9) | 109.1 (22.6) | 0.003** | −11.6 (−5.0 to −18.2) | −0.53 (−1.39 to −0.34) | M | 5.5 | Yes |
| Peak Torque (Nm)—Non-dominant leg at 90° | 115.5 (18.8) | 103.8 (23.5) | 0.005** | −11.7 (−4.3 to −19.1) | −0.53 (−1.39 to −0.33) | M | 7.2 | Yes |
| Peak Force (N)—Dominant leg at 30° | – | – | – | – | – | – | – | – |
| Peak Force (N)—Non-dominant leg at 30° | – | – | – | – | – | – | – | – |
| Peak Torque (Nm)—Dominant leg at 30° | – | – | – | – | – | – | – | – |
| Peak Torque (Nm)—Non-dominant leg at 30° | – | – | – | – | – | – | – | – |
| **Countermovement jump test** | | | | | | | | |
| Jump Height (cm) | 39.5 (4.6) | 38.4 (5.0) | 0.005** | −1.1 (−1.9 to −0.4) | −0.22 (−1.03 to 0.59) | S | 1.4 | No |
| Contraction Time (ms) | 692.1 (76.7) | 720.9 (89.1) | 0.236 | 28.8 (−21.5 to 79.2) | 0.34 (−0.48 to 1.15) | S | 46.4 | No |
| RSImodified (m/s) | 0.58 (0.11) | 0.55 (0.11) | 0.013* | −0.03 (−0.06 to 0.01) | −0.26 (−1.08 to 0.55) | S | 0.03 | Yes |
| Concentric Duration (ms) | 244.2 (31.6) | 245.9 (30.6) | 0.756 | 1.7 (−9.8 to 13.1) | 0.05 (−0.76 to 0.86) | T | 17.8 | No |
| Concentric Peak Force (N) | 1,843.2 (185.1) | 1,765.7 (181.5) | 0.008** | −77.5 (−130.5 to −24.5) | −0.41 (−1.23 to 0.41) | S | 86.3 | No |
| Concentric Peak Velocity (m/s) | 2.86 (0.15) | 2.82 (0.17) | 0.051 | −0.04 (−0.07 to 0.00) | −0.24 (−1.05 to 0.57) | S | 0.06 | No |
| Concentric Mean Power (W) | 2,239.3 (315.4) | 2,141.2 (290.1) | 0.000*** | −98.1 (−142.2 to −54.0) | −0.31 (−1.13 to 0.50) | S | 87.9 | Yes |
| Peak Power (W) | 3,981.9 (523.7) | 3,943.9 (483) | 0.282 | −38.0 (−111.6 to 35.6) | −0.07 (−0.88 to 0.74) | T | 141.0 | No |
| Eccentric Duration (ms) | 447.8 (56) | 475.1 (66.2) | 0.173 | 27.2 (−13.7 to 68.2) | 0.43 (−0.39 to 1.25) | S | 29.0 | No |
| Eccentric Braking Phase Duration (s) | 0.27 (0.05) | 0.29 (0.05) | 0.212 | 0.02 (−0.01 to 0.05) | 0.35 (−0.47 to 1.16) | S | 0.03 | No |
| Eccentric Deceleration Phase Duration (s) | 0.15 (0.03) | 0.17 (0.03) | 0.089 | 0.02 (−0.00 to 0.04) | 0.65 (−0.19 to 1.48) | M | 0.02 | No |
| Eccentric Mean Braking Force (N) | 888.6 (77.5) | 850.3 (75.1) | 0.025* | −38.3 (71.0 to −5.6) | −0.49 (−1.31 to 0.34) | S | 32.7 | Yes |
| Eccentric Mean Deceleration Force (N) | 1,344.7 (151.1) | 1,229.9 (133.2) | 0.002** | −114.8 (−178.7 to −50.9) | −0.78 (−1.62 to 0.06) | M | 74.0 | Yes |
| Eccentric Peak Force (N) | 1,769.8 (213.1) | 1,621.2 (194.7) | 0.000*** | −148.6 (−205.4 to −91.8) | −0.71 (−1.54 to 0.13) | M | 97.2 | Yes |
| Force at Zero Velocity (N) | 1,761 (215.2) | 1,613.6 (194.4) | 0.000*** | −147.4 (−204.9 to −89.8) | −0.70 (−1.53 to 0.14) | M | 99.4 | Yes |
| Eccentric Mean Power (W) | 487.5 (76.7) | 442.1 (65.9) | 0.005** | −45.5 (−74.0 to −16.9) | −0.61 (−1.44 to 0.22) | M | 34.3 | Yes |

CI, confidence intervals; TE, typical error of measurement; ES, effect size; T, trivial; S, small; M, moderate, RSI, reactive strength index.
Sensitivity to change: absolute change at post-match >TE x 1.5 (Hopkins, 2000).
*$p \leq 0.05$.
**$p \leq 0.01$.
***$p \leq 0.001$.

(44). Considering that neuromuscular fatigue is one potential hamstring strain injury risk factor, our findings support the use of IPC test to indirectly monitor post-match neuromuscular function in youth soccer population.

A key finding of the present study was that CMJ eccentric phase measures had greater post-match changes compared with CMJ jump height and concentric phase measures. In line with previous studies on elite youth soccer players (6, 45), jump height showed a significant reduction but demonstrated limited sensitivity by displaying post-match changes similar to the typical variation. It has been reported that jump height may not be sensitive to training and match loads in elite soccer players (26, 46). Therefore, CMJ time-based measures may hold superior sensitivity to change following official matches and fatiguing intermittent protocol (22, 28). Our analysis of CMJ measures revealed that RSImod, eccentric forces (EccMBF, EccMDecF, EccPF, F@0 V) and mean power (ConcMP, EccMP) demonstrated an acceptable level of sensitivity displaying changes greater than the typical variation (i.e., 1.5 times the TE). Gathercole and colleagues demonstrated a similar level of sensitivity to alternative CMJ measures in a group of collegiate team sports athletes showing acute changes greater than their typical variation and confidence intervals (28). The observed responses suggest that elite youth soccer players may experience acute reductions in neuromuscular function which have been attributed to a reduced central drive and metabolic disturbances that impair excitation-contraction coupling and reduce stretch-reflex sensitivity, muscle stiffness, and force production (47). The greater magnitude of change of CMJ eccentric forces may be associated with the frequent intense acceleration and deceleration actions performed during the match (48, 49). Overall, the acute changes in time-based measures may reflect the altered stretch-shortening cycle (SSC) function and movement strategy employed over the downward phase of the CMJ (47). The current findings demonstrate CMJ eccentric force measures may reveal alterations in jump strategy which underline the presence of altered SSC and neuromuscular fatigue following match-play. As time, force and velocity used to perform soccer-specific actions are considered fundamental for success in elite soccer, these alterations in CMJ eccentric force measures may have relevant implications in monitoring players' physical performance.

This study provides practitioners with a range of physical performance measures suitable for indirectly monitoring players' post-match neuromuscular status in elite youth soccer players. It is important to highlight the main limitations inherent to this work. Despite the ecological validity of the study, sensitivity to change was evaluated using a single match of a shorter duration compared to the official match (i.e., 80 vs. 90 min), with match

demands inherently variable between players. Thus, match demands might have influenced the magnitude of alterations post-match. Another limitation of our study is the lack of investigation into the association between changes in physical performance and match demands. Examining this association may provide valuable insights for predicting post-match acute and residual fatigue (49). Additionally, it is important to emphasize that our study was conducted with players from one club only, limiting the generalizability of our results to other youth soccer academy settings. Future research should investigate the time course of recovery of these neuromuscular measures in the days following the match and examine the effects of different recovery interventions on these measures in the subsequent days following match play (i.e., match-day + 1 and match-day + 2) as little research exists in elite youth soccer (50).

## 5. Practical applications

The present study demonstrated that IPC and CMJ tests are reliable and sensitive tools for monitoring post-match changes in physical performance of elite youth soccer players. Our findings indicated that IPC peak force and torque, CMJ RSImod, CMJ eccentric measures (EccMBF, EccMDecF, EccPF, F@0 V) and CMJ mean power may be more appropriate to detect physical performance changes following match-play. Conversely, typically reported CMJ measures such as jump height and peak power showed limited sensitivity in detecting post-match changes. Performance practitioners are therefore encouraged to include such measures for monitoring neuromuscular performance following the match. This might allow coaches and scientists to optimize the scheduling of training across the microcycle, facilitating recovery whilst also optimizing the physical conditioning of players.

## 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 University Research Ethics Committee, Liverpool John Moores University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

## Author contributions

Authors contributed to this manuscript as follows: study conception and design (AF, MAR, KE); data collection (AF, DFB); data curation (AF, MAR); data analysis (AF, MAR, KE); supervision (DFB, KE); writing—original draft (AF); writing—review, editing and approval of final draft (AF, MAR, DO, TB, DFB, KE). All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2023.1173621/full#supplementary-material

## References

1. Kelly DM, Strudwick AJ, Atkinson G, Drust B, Gregson W. Quantification of training and match-load distribution across a season in elite English premier league soccer players. *Sci and Med in Football*. (2020) 4(1):59–67. doi: 10.1080/24733938.2019.1651934

2. Hannon MP, Coleman NM, Parker LJF, Mckeown J, Unnithan VB, Close GL, et al. Seasonal training and match load and micro-cycle periodization in male premier league academy soccer players. *J Sports Sci*. (2021) 00(00):1–12. doi: 10.1080/02640414.2021.1899610

3. Silva JR, Rumpf MC, Hertzog M, Castagna C, Farooq A, Girard O, et al. Acute and residual soccer match-related fatigue: a systematic review and meta-analysis. *Sports Med*. (2018) 48(3):539–83. doi: 10.1007/s40279-017-0798-8

4. Rampinini E, Bosio A, Ferraresi I, Petruolo A, Morelli A, Sassi A. Match-related fatigue in soccer players. *Med Sci Sports Exerc*. (2011) 43(11):2161–70. doi: 10.1249/MSS.0b013e31821e9c5c

5. Deely C, Tallent J, Bennett R, Woodhead A, Goodall S, Thomas K, et al. Etiology and recovery of neuromuscular function following academy soccer training. *Front Physiol*. (2022) 13:911009. doi: 10.3389/fphys.2022.911009

6. de Hoyo M, Cohen DD, Sañudo B, Carrasco L, Álvarez-Mesa A, del Ojo JJ, et al. Influence of football match time–motion parameters on recovery time course of muscle damage and jump ability. *J Sports Sci*. (2016) 34(14):1363–70. doi: 10.1080/02640414.2016.1150603

7. Castellano J, Martin-Garcia A, Casamichana D. Most running demand passages of match play in youth soccer congestion period. *Biol Sport*. (2020) 37(4):367–73. doi: 10.5114/biolsport.2020.96853

8. Dupont G, Nedelec M, McCall A, McCormack D, Berthoin S, Wisløff U. Effect of 2 soccer matches in a week on physical performance and injury rate. *Am J Sports Med*. (2010) 38(9):1752–8. doi: 10.1177/0363546510361236

9. Thorpe RT, Atkinson G, Drust B, Gregson W. Monitoring fatigue status in elite team-sport athletes: implications for practice. *Int J Sports Physiol Perform*. (2017) 12: S227–34. doi: 10.1123/ijspp.2016-0434

10. Enoka RM, Duchateau J. Translating fatigue to human performance. *Med Sci Sports Exerc*. (2016) 48(11):2228–38. doi: 10.1249/MSS.0000000000000929

11. Alba-Jiménez C, Moreno-Doutres D, Peña J. Trends assessing neuromuscular fatigue in team sports: a narrative review. *Sports*. (2022) 10(3):33. Available at: https://www.mdpi.com/2075-4663/10/3/33 doi: 10.3390/sports10030033

12. Norris D, Joyce D, Siegler J, Cohen D, Lovell R. Considerations in interpreting neuromuscular state in elite level Australian rules football players. *J Sci Med Sport*. (2021) 24(7):702–8. doi: 10.1016/j.jsams.2021.02.007

13. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med*. (2000) 30(1):1–15. doi: 10.2165/00007256-200030010-00001

14. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Medicine*. (1998) 26 (4):217–38. doi: 10.2165/00007256-199826040-00002

15. Impellizzeri FM, Marcora SM. Test validation in sport physiology: lessons learned from clinimetrics. Vol. 4, *Int J Sports Physiol Perform*. Human Kinetics Publishers Inc.; (2009). p. 269–77. doi: 10.1123/ijspp.4.2.269

16. Howarth DJ, Cohen DD, McLean BD, Coutts AJ. Establishing the noise: interday ecological reliability of countermovement jump variables in professional rugby union players. *J Strength Cond Res*. (2022) 36(11):3159–66. doi: 10.1519/JSC.0000000000004037

17. Mercer RAJ, Russell JL, Mcguigan LC, Coutts AJ, Strack DS, Mclean BD. Finding the signal in the noise-interday reliability and seasonal sensitivity of 84 countermovement jump variables in professional basketball players. *J Strength Cond Res*. (2023) 37(2):394–402. doi: 10.1519/JSC.0000000000004182

18. Bishop C, Turner AN, Jordan M, Harry J, Loturco I, Lake J, et al. A framework to guide practitioners when selecting metrics during the countermovement and drop jump tests. *Strength Cond J*. (2022) 44(4):95–103. doi: 10.1519/SSC.0000000000000677

19. Enright K, Morton J, Iga J, Lothian D, Roberts S, Drust B. Reliability of "in-season" fitness assessments in youth elite soccer players: a working model for practitioners and coaches. *Sci and Med in Football*. (2018) 2(3):177–83. doi: 10.1080/24733938.2017.1411603

20. Fitzpatrick JF, Hicks KM, Russell M, Hayes PR. The reliability of potential fatigue-monitoring measures in elite youth soccer players. *J Strength Cond Res*. (2021) 35(12):3448–52. doi: 10.1519/JSC.0000000000003317

21. Brown AM, Hader K, Guilhem G, Simpson BM, Buchheit M, Lacome M. The ballistic hip thrust test: a potential tool to monitor neuromuscular performance. *Biol Sport*. (2022) 39(1):73–7. doi: 10.5114/biolsport.2021.102920

22. Rowell AE, Aughey RJ, Hopkins WG, Stewart AM, Cormack SJ. Identification of sensitive measures of recovery after external load from football match play. *Int J Sports Physiol Perform*. (2017) 12(7):969–76. doi: 10.1123/ijspp.2016-0522

23. Beattie CE, Fahey JT, Pullinger SA, Edwards BJ, Robertson CM. The sensitivity of countermovement jump, creatine kinase and urine osmolality to 90-min of competitive match-play in elite English championship football players 48-h post-match. *Sci Med Footb*. (2021) 5(2):165–73. doi: 10.1080/24733938.2020.1828614

24. Franceschi A, Conte D, Airale M, Sampaio J. Training load, neuromuscular readiness, and perceptual fatigue profile in youth elite long-jump athletes. *Int J Sports Physiol Perform*. (2020) 15(7):1034–8. doi: 10.1123/ijspp.2019-0596

25. Thorpe RT, Strudwick AJ, Buchheit M, Atkinson G, Drust B, Gregson W. Monitoring fatigue during the in-season competitive phase in elite soccer players. *Int J Sports Physiol Perform*. (2015) 10(8):958–64. doi: 10.1123/ijspp.2015-0004

26. Malone JJ, Murtagh CF, Morgans R, Burgess DJ, Morton JP, Drust B. Countermovement jump performance is not affected during an in-season training microcycle in elite youth soccer players. *J Strength Cond Res*. (2015) 29(3):752–7. doi: 10.1519/JSC.0000000000000701

27. Bishop C, Jordan M, Torres-Ronda L, Loturco I, Harry J, Virgile A, et al. Selecting metrics that matter: comparing the use of the countermovement jump for performance profiling, neuromuscular fatigue monitoring, and injury rehabilitation testing. *Strength Cond J*. (2023). doi: 10.1519/SSC.0000000000000772. [Epub ahead of Print].

28. Gathercole R, Sporer B, Stellingwerff T, Sleivert G. Alternative countermovement-jump analysis to quantify acute neuromuscular fatigue. *Int J Sports Physiol Perform*. (2015) 10(1):84–92. doi: 10.1123/ijspp.2013-0413

29. Heishman AD, Daub BD, Miller RM, Freitas EDS, Frantz BA, Bemben MG. Countermovement jump reliability performed with and without an arm swing in NCAA division 1 intercollegiate basketball players. *J Strength Cond Res*. (2020) 34 (2):546–58. doi: 10.1519/JSC.0000000000002812

30. Brownlee TE, Murtagh CF, Naughton RJ, Whitworth-Turner CM, O'Boyle A, Morgans R, et al. Isometric maximal voluntary force evaluated using an isometric mid-thigh pull differentiates English premier league youth soccer players from a maturity-matched control group. *Sci and Med in Football*. (2018) 2(3):209–15. doi: 10.1080/24733938.2018.1432886

31. Barnes C, Archer DT, Hogg B, Bush M, Bradley PS. The evolution of physical and technical performance parameters in the English premier league. *Int J Sports Med*. (2014) 35(13):1095–100. doi: 10.1055/s-0034-1375695

32. Huygaerts S, Cos F, Cohen DD, Calleja-González J, Guitart M, Blazevich AJ, et al. Mechanisms of hamstring strain injury: interactions between fatigue, muscle activation and function. *Sports*. (2020) 8(5):65. doi: 10.3390/sports8050065

33. Trecroci A, Porcelli S, Perri E, Pedrali M, Rasica L, Alberti G, et al. Effects of different training interventions on the recovery of physical and neuromuscular performance after a soccer match. *J Strength Cond Res*. (2020) 34(8):2189–92. doi: 10.1519/JSC.0000000000003269

34. McCall A, Nedelec M, Carling C, le Gall F, Berthoin S, Dupont G. Reliability and sensitivity of a simple isometric posterior lower limb muscle test in professional football players. *J Sports Sci*. (2015) 33(12):1298–304. doi: 10.1080/02640414.2015.1022579

35. Cuthbert M, Comfort P, Ripley N, Mcmahon JJ, Evans M. Unilateral vs. Bilateral hamstring strength assessments : comparing reliability and inter-limb asymmetries in female soccer players. *J Sports Sci*. (2021) 39(13):1481–8. doi: 10.1080/02640414.2021.1880180

36. Constantine E, Taberner M, Richter C, Willett M, Cohen DD. Isometric posterior chain peak force recovery response following match-play in elite youth soccer players: associations with relative posterior chain strength. *Sports (Basel)*. (2019) 7(10):218. doi: 10.3390/sports7100218

37. McMahon JJ, Suchomel TJ, Lake JP, Comfort P. Understanding the key phases of the countermovement jump force-time curve. *Strength Cond J*. (2018) 40(4):96–106. doi: 10.1519/SSC.0000000000000375

38. Claudino JG, Cronin J, Mezêncio B, Mcmaster DT, Mcguigan MR, Tricoli V, et al. The countermovement jump to monitor neuromuscular status: a meta-analysis. *J Sci Med Sport*. (2017) 20(4):397–402. doi: 10.1016/j.jsams.2016.08.011

39. Weir J. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *J Strength Cond Res*. (2005) 19(1):231–40. doi: 10.1519/15184.1

40. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. (2016) 15(2):155–63. doi: 10.1016/j.jcm.2016.02.012

41. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. (2009) 41 (1):3–12. doi: 10.1249/MSS.0b013e31818cb278

42. Baltzopoulos B, King M, Gleeson N, de Ste Croix M. The BASES expert statement on measurement of muscle strength with isokinetic dynamometry. *The Sport and Exercise Scientist*. (2012) 31:12–3.

43. Wollin M, Thorborg K, Pizzari T. The acute effect of match play on hamstring strength and lower limb flexibility in elite youth football players. *Scand J Med Sci Sports*. (2017) 27(3):282–8. doi: 10.1111/sms.12655

44. Owens DJ, Twist C, Cobley JN, Howatson G, Close GL. Exercise-induced muscle damage: what is it, what causes it and what are the nutritional solutions?. *Eur J Sport Sci*. (2019) 19(1):71–85. doi: 10.1080/17461391.2018.1505957

45. Romagnoli M, Sanchis-Gomar F, Alis R, Risso-Ballester J, Bosio A, Graziani RL, et al. Changes in muscle damage, inflammation, and fatigue-related parameters in young elite soccer players after a match. *J Sports Med Phys Fitness*. (2016) 56(10):1198–205.

46. Thorpe RT, Strudwick AJ, Buchheit M, Atkinson G, Drust B, Gregson W. The influence of changes in acute training load on daily sensitivity of morning-measured fatigue variables in elite soccer players. *Int J Sports Physiol Perform*. (2017) 12(Suppl 2):S2107–13. doi: 10.1123/ijspp.2016-0433

47. Komi PV. Stretch-shortening cycle: a powerful model to study normal and fatigued muscle. *J Biomech*. (2000) 33(10):1197–206. doi: 10.1016/S0021-9290(00)00064-6

48. Harper DJ, Carling C, Kiely J. High-Intensity acceleration and deceleration demands in elite team sports competitive match play: a systematic review and meta-analysis of observational studies. *Sports Med*. (2019) 49(12):1923–47. doi: 10.1007/s40279-019-01170-1

49. Hader K, Rumpf MC, Hertzog M, Kilduff LP, Girard O, Silva JR. Monitoring the athlete match response: can external load variables predict post-match acute and residual fatigue in soccer? A systematic review with meta-analysis. *Sports Med Open*. (2019) 5(1):48. doi: 10.1186/s40798-019-0219-7

50. Calleja-González J, Mielgo-Ayuso J, Miguel-Ortega Á, Marqués-Jiménez D, del Valle M, Ostojic SM, et al. Post-exercise recovery methods focus on young soccer players: a systematic review. *Front Physiol*. (2021) 12:505149. doi: 10.3389/fphys.2021.505149

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# The relationships between relative age effect, personality constructs and achievement level in soccer

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**Introduction:** Youth soccer academies are challenged with the constant recruitment process of young talented players to select those who will achieve long-term success as an athlete. Youth soccer academies strive to enhance the physical and technical skill development as well as personality development of talented players because psychological characteristics play a crucial role in players' future success in their transition to professional soccer. The least mature players and relatively young players may have a greater need to possess superior technical/tactical or psycho-behavioral skills than those relatively older counterparts because of the higher selection rates of early maturing players. Due to RAEs, a significant decrease in the overall quality of professional soccer teams might be observed because of the loss of talent of physically smaller, but psychologically stronger and more versatile relatively young players who possess proper technical and tactical attributes at an early age. The first objective of this study was to examine any possible relationship between RAE and personality constructs. A second objective was to identify factors and effects that can help in the further improvement of talent selection and equal opportunities for elite youth soccer players based on their underlying RAE. The third objective was to consider the impact of RAE on long-term career development.
**Methods:** In this retrospective observational study, 151 elite youth soccer players between 15 and 18 years of age were first grouped in birth quartiles. Personality constructs were then assessed, using a combination of observations, interviews, and a self-assessment questionnaire. Next competition level after 8 years was evaluated to identify RAEs, differences in personality characteristics and opportunities to reach professional soccer player status between relatively older vs. younger players.
**Results:** A clear significant RAE was observed for the whole database (Q1 = 38.4% vs. Q4 = 13.9%) with OR of 2.61 ($\chi^2 = 19.46$, $p < 0.01$, $r = -0.85$). Relatively young players had higher median scores on personality constructs such as self-confidence ($p = 0.04$), while relatively old players had higher median scores on personality constructs such as team orientation ($p = 0.03$). In the long term, more players of the youngest birth quartile were signed as professional players (76.2%), compared with relatively old players (46.6%). 65.0% of the 20 players had the highest total score on personality constructs developed as a professional soccer player, vs. 35.0% of the 20 players with the lowest scores.
**Discussion:** In conclusion, this study showed not only further evidence of the RAE but also provided evidence supporting "the underdog hypothesis" in national elite youth teams. Relatively young players were also more likely to get higher value senior professional contracts in the long term. We propose that this may be due to the relatively young players developing superior psychological skills and technical expertise to compensate for their early physical disadvantage. This in

turn suggests the need for greater awareness of the importance of personality constructs in the future development of youth elite soccer players. Therefore, the crux of the issue is how youth soccer academies elicit the "best of both worlds" ie. moderating RAE whilst also gaining the benefits of the underdog hypothesis by creating the right environment for every player to develop to their full potential in elite youth soccer academies.

KEYWORDS

individual differences, long-term career, well-being, underdog hypothesis, talent identification

## Introduction

Youth soccer academies, are constantly challenged with recruitment of young talented players to select those who will achieve long-term success as an athlete (1–4). Because of their continuous growth process, children are most often grouped according to their chronological age in education and sports settings, including soccer (5). In the Flemish educational system, pupils are also organised into one-year age groups, using January 1 as the cut-off date. Although, maturational effects during puberty may be responsible for potentially large development differences between chronological and biological age, described as relative age effect (RAE) (5–7). This is especially true for sports where physical characteristics are important, as in soccer, which then results in a selective advantage for those with early maturation (6, 8, 9).

Despite the crucial role of physical performance in talent selection, other areas of performance (technical, tactical, psychological, or cultural) are as important to fully assess a player's quality and long-term development potential. A multifactorial assessment is is essential (1–3, 10).

The first aim of this study was to examine a possible relationship between RAE and personality characteristics. A second purpose was to identify factors that can help improve talent selection and equal opportunities for elite youth soccer players given their underpinning RAE. Next, the impact of RAE on long-term career development for this group of players was assessed, with the hypothesis that relatively younger players that are selected to play on an elite team have the advantage of receiving higher quality soccer education, described as the "underdog hypothesis" (11).

The RAE in sports is a global phenomenon and is present in the majority of sports where physical characteristics are important (11–13). Selection biases because of the RAE, likely lead to homogenous pools of players selected for academy soccer programs who are often either relatively old and/or who are early maturing in comparison to population norms (6, 9, 14, 15). These early maturing players are frequently characterized as possessing temporary, maturity-related advantages both in anthropometric (e.g., stature and body mass) and physical fitness characteristics (e.g., power, strength, speed) (7, 16–18).

Coaches and scouts have the intention to select relatively old players who are physically stronger or bigger at the time of selection and are therefore more likely to be perceived as "talented" and subsequently selected for talent development programmes without considering their long-term potential (1, 2, 16, 18, 19). This compromises the selection of players with greater potential in the long-term, who were born towards the end of the year (19). Helsen et al. (19) also demonstrated that relatively old children were more likely to get extra opportunities such as advanced levels of coaching, transfers to better teams, and more frequently being selected for experiential opportunities, or becoming a professional soccer player.

Boccia et al. (20) revealed that most players in elite senior teams were not selected for elite youth teams before, which suggests that junior-to-senior transition is not determined by youth national team selections. The RAE influences strongly the selection for national youth teams, but its impact was clearly smaller in the youth-to-senior transition. Brustio et al. (21) revealed that only a few players, selected in the Italian female national youth teams, reached the Italian female national senior team. They also remarked that the RAE in U17 and U19 with a playing position's effect in the younger age categories, became smaller in the national senior teams.

Conversely relatively young children were more likely to drop out early (9, 19). In the long-term, a clear decrease in the overall quality of the highest competitive teams will be present since talented players with proper technical attributes are overlooked at an early age due to a lack of physical development which is simply related to the period of the selection year in which they were born. Selection in talent development systems is not only associated with receiving better education, experience, and coaching, but also facing stronger opponents. Because higher competition is more prestigious and challenging, it is also likely to increase one's motivation and self-esteem (1, 6, 19, 22, 23).

A combination of physical, cognitive, emotional, and motivational factors accumulate to produce RAEs and maturity selection bias (1, 4, 6, 24). Many promising and talented players have been overlooked in the past because they suffered from a relative age disadvantage in their early childhood often during selection procedures in talent academies (19). The long-term effect of RAEs likely produce a significant decrease in the overall quality of the highest competitive professional teams since smaller, psychologically stronger players with proper technical attributes are overlooked at an early age due to a lack of physical development, that is simply related to the period of the selection year in which they were born.

It should be recognized that the determinants of the RAE are multifactorial (14, 25, 26). Psychological characteristics, that underlie the RAE in greater depth through various social agents,

have been integrated into models of talent identification and development as significant predictors of success in sports of players (12).

The way in which these social agents (parents, coaches, and athletes) interpret mechanisms such as physical stature, maturity, and cognitive ability creates RAEs through various effects such as the Pygmalion, Galatea, and Matthew effects (12). As such it is essential that the influence on psychological and cognitive parameters also needs to be factored in, since we know that psychological factors are important to scouts and coaches during the talent selection process (1, 2). The development of physical performance skills stays a crucial element of talent identification. However, other parts of performance (technical, tactical, psychological, or social) are also important selection parameters to properly evaluate a player's quality and potential long-term development and can assist talent identification and development (1, 4).

Youth soccer academies are the main talent development institutions for professional youth soccer all over the world. Their main aim is to recruit young talented players with the potential to be developed into professional soccer players and to achieve long-term success. Therefore, it is important to better understand why certain players are more likely to be selected into an academy, and also why others might be more likely to successfully graduate as a long-term successful player. The current study provides further evidence of the relative age effect within national elite football teams but goes further and demonstrates an association between the RAE and personality constructs in elite Belgian youth soccer players. It is important to identify personality characteristics for long-term success as an early- or late-maturing soccer player so that the most talented youth soccer players receive continued progressive support from a young age to achieve their maximum potential (22, 27–29). The relationship between the RAE and the long-term career development of the elite youth soccer players was determined. Current literature suggests that the RAE reverses throughout the career of athletes, with relatively younger players having more opportunities to reach professional status (30).

The current state of empirical research shows that psychological characteristics and skills such as motivational orientation, self-reflection, self-regulation, self-confidence and competition anxiety differ between youth players of different performance levels (22, 31, 32). Kavussanu et al. demonstrated that differences between players were largely due to higher performing players' greater task orientation (33). Previous studies in soccer determined self-confidence was relevant for high performance (32, 34). Concerning emotional stability, previous research has focused on anxiety as an important factor that can influence higher soccer performance (32). Also self-regulation has been found relevant for future performance (22). Höner et al. revealed significant relationships between psychological components such as motivation, volition and self-referential cognition with future performance level; whereas competition anxiety revealed only a weak relationship with performance level (35, 36). Previous research has also demonstrated that elite youth soccer players possess more adaptive self-regulation than non-elite players, suggesting that self-regulation contributes significantly towards success in sport (22, 37).These authors also reported that elite players showed higher levels of reflection and effort, and appeared more willing to invest effort into task execution and adapting their knowledge and actions in order to execute skills (22). Likewise, lack of self-regulated skills has been shown to negatively impact performance outcomes in sport (38).

This study provides further evidence that psychological skills training is essential to both improving and increasing the consistency of performance; which in turn is of benefit to the development of the player, coach, and team homogeneity (39). The findings also support the importance of specific psychological skills training within different levels of maturity, development, and position in the soccer team (1, 27).

The complex nature of the talent development process, together with the multifactorial characteristics associated with superior talent development and the successful transition from youth academy level to senior professional player status, suggests that personality and psychological characteristics are very important in soccer because they may influence all the athlete's performance subcomponents and opportunities to develop as a professional player.

# Methods

## Study population

A retrospective observational study was conducted on 154 male elite Belgian youth soccer players (aged between 15 and 18 years), born between 1990 and 1996 (1990: $n = 1$, 1991: $n = 19$, 1992: $n = 27$, 1993: $n = 32$, 1994: $n = 32$, 1995: $n = 22$, 1996: $n = 18$), who were playing in the Belgian national youth teams U16-U19. Ethical approval was obtained (008185).

Players' charts were reviewed and data were collected regarding date of birth. Data were collected between March 2010 and February 2012. Three players were excluded from data analysis (deceased (2 players; traffic accident, sudden cardiac death), incomplete data (1 player)). These deselections resulted in a sample of 151 elite Belgian youth soccer players.

At the time of data collection, all players were involved in the Belgian national youth teams. The data were originally collected by the Royal Belgian Football Association (RBFA) to improve coaches' individualized approach to players and to help players enhance their mental capabilities.

## Study design

Players were grouped within each category according to the Belgian domestic soccer season birthdate quartiles (Q1: January 1st to March 31st; Q2: April 1st to June 30th; Q3: July 1st to September 30th; Q4: October 1st to December 31st) and represented as a percentage of the sample population. Players'

date of birth was collected from charts of the Royal Belgian Football Association (RBFA) and categorized into birthdate quartiles (Q).

## Design of the psychological assessments

During the first phase, the youth soccer players were interviewed and analyzed by two sports psychologists between March 2010 and February 2012 according to guidelines stating that psychological characteristics should be evaluated by combining players' self-rating and external expert rating in talent development and psychological analysis (27). The players also performed a self-assessment by filling out the "Mental Potential Questionnaire" and the "Task & Ego Orientation in Sports Questionnaire" (TEOSQ) (40). These questionnaires are based on the NEO-FFI-3 Questionnaire, which contains 60 questions and provides an accurate measure of the 5 domains of personality (neuroticism, extraversion, openness, agreeableness, conscientiousness). It can help you to understand a player's emotional, interpersonal, attitudinal, experiential and motivational approach. The players can complete the questionnaires by indicating how much they agree with each statement by entering an appropriate score (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree). It is a dimensional representation of personality structure to analyze personality disorder scales. The "Mental Potential Questionnaire" is based on "The Athletic Coping Skills Inventory" ("ACSI") and is a highly validated psychology assessment that measures an athlete's psychological coping skills in training and competition in seven key areas coping with adversity, coachability, concentration, confidence and achievement motivation, goal setting and mental preparation, peaking under pressure and freedom from worry. Players will answer a list of 28 questions surrounding the 7 different personality constructs, by which personality constructs are measured by 4 questions each. These questions are answered by means of a 4-points scale (0: almost never, 1: sometimes, 2: often, 3: almost always). The final score for each subscale can range from 0 to 12, while the final summation of all the scores for each skill creates a value ranging from 0 to 84 called the Personal Coping Resource. Higher scores in these tests are indicative of the ability to cope with the demands of the sport and to possess greater psychological skills and personality constructs. Afterward, each player was observed by the two sports psychologists during two matches and three training sessions. The psychologists observed the youth players independently from one another before comparing notes and agreeing on a consensus score on the different personality characteristics of each player. The personality constructs of the players were analyzed by two experienced sports psychologists, which are trained to make an objective evaluation of the different personality constructs without being influenced by external factors like the opponent or match outcome. Moreover, players are observed during two matches and three training sessions in order to evaluate how players manage their emotions and concentration in different match and training situations, against different opponents and by different match outcomes. Finally, a one-hour competency-based interview was conducted with each player using the critical incident technique (CIT) (41). In that interview, the soccer players were questioned about six personality characteristics: self-confidence, winning mindset, self-development, managing emotions, concentration, and team orientation. By giving examples of situations in which those constructs were applied during training sessions and matches, the psychologist assessed the personality constructs of the players. The CIT is based on the recall of an actual event in order to examine the likely behavior of players in certain situations. The technique is useful when it is likely that attitudes or behavior would be less likely to be revealed using a direct approach. During a final discussion, the psychologists combined data from the observations, questionnaires, and interviews to score the youth soccer players on the six personality constructs, with each method accounting for one-third of the total score. For each personality construct, players were scored on a nine-point standard scale. A final score ranging between 1 and 3, will indicate that the player's mental skill is insufficiently developed and will have a negative impact on their performance as football player. A score between 4 and 6, will indicate that this mental skill is sufficiently developed, comparable to most elite players and contributes to their performance in a positive way.

Finally, a score between 7 and 9, can indicate that this personality construct is a real strength, in which you are better than most other players.

Based on the player's results, they will receive an individual report with evaluations and recommendations developed by our licensed sport psychologists.

During the second phase, in February 2019, the players' current playing level was evaluated. They were divided into the following competition levels: professional players abroad, first division Jupiler Pro League, second division 1B, amateur, lower rankings, or no club. This allowed us to examine the potential correlation between their personality constructs, their birthdate quartile, and the highest level of competition they reached in their long-term career development.

## Personality constructs

Psychological constructs, which include personality traits and psychological skills, are relevant predictors of future soccer performance in talent development (1, 27).

The six characteristics were chosen by two experts in the field of sports psychology and the RBFA. They reflect the personality characteristics which play a crucial role in players' future success. Personality traits are defined as a predisposition to behave in a certain way. Definitions are based on descriptions from the ACSI and "The Big Five" (42, 43).

The six constructs were defined as:

- Self-confidence: showing faith in one's skills, the courage to meet difficult situations, and the pleasure one has in playing soccer

- Winning mindset: the ability to make efforts and to demonstrate discipline to achieve challenging goals, the will to win, the motivation to succeed, and the dedication to the sport. It also includes perseverance after a setback.
- Self-development: showing insight into one's strengths and pitfalls, accepting advice and feedback from others, willing and daring to question oneself, and taking responsibility for one's development.
- Managing emotions: positively using one's emotions and performing under pressure.
- Concentration: the ability to focus on a task and not be distracted by external or internal factors.
- Team orientation: integrating into the group and making a positive contribution to the team atmosphere. It also involves clear and constructive communication, giving advice and feedback to teammates, motivating others in case of setbacks, and showing that group interests predominate over individual interests.

## Statistical analysis

The 151 players were grouped within categories according to typical Belgian domestic soccer season birthdate quartiles depending on their date of birth and expressed as a percentage of the sample population with a cut-off date of January 1st. Statistical analyses were performed to examine the relative age effect of the whole data set. Results were represented as median values. RAE was determined using odds ratios (OR). To verify if there was an RAE, the results were compared with the birth rates of the general Belgian population from 1990 to 1996. The Chi-square test, the Kolmogorov-Smirnov test, and the correlation coefficient were applied to ensure the significance of the RAE results ($p < 0.01$).

Subsequently, the median of the scores for each personality construct was calculated for every birth quarter as well as for the first and last half of the year (semester). The one-tailed Mann–Whitney $U$ test was conducted to check if there was a significant difference ($p < 0.05$) between the corresponding medians.

A contrastive analysis was performed on the players' long-term playing level: the 20 best and 20 worst scoring players on the personality characteristics were identified and compared, concerning the current competition level. The same analysis was also performed on the current playing levels per birthdate quarter, to evaluate which birthdate quarter players achieve more frequently senior professional contracts.

A multiple stepwise regression analysis was carried out to investigate which parameters contribute independently the most to predict professional future performance.

# Results

151 elite soccer players between 15 and 18 years old were grouped within each category according to the Belgian domestic soccer season birthdate quartiles between 2010 and 2012 with a re-evaluation of the long-term playing level after a mean follow-up time of 8 years.

## Do these data also show a relative age effect?

The age distribution of our study population showed a RAE for the overall dataset (**Figure 1**). **Figure 1** shows that there was a significant difference in the distribution of players according to a birth quarter ($p < 0.01$). There was a dominance of players that were born in Q1 (38.4%), followed by players born in Q2 (26.5%), Q3 (21.2%), and Q4 (13.9%). The RAE was also clearly present in all the different individual age categories (1990–1996). The magnitude of the RAE was 2.61 (OR: 2.61; 95%CI: 1.14–5.98) for the overall sample of youth players (Q1 = 38.4% vs. Q4 = 13.9%), which can be correlated with a medium effect size. An uneven distribution was identified for each annual group, with 31.2%–50.0% of players born in Q1 and 4.5%–21.9% in Q4. %. The distribution of the soccer players, on the other hand, showed a statistically significant difference between the percentage of observed soccer players from the first quartile vs. the percentage of the last quartile, respectively 38.4% (58/151) vs. 13.9% (21/151) (**Figure 1**).

These asymmetric birthdate distributions, presenting the RAE, were statistically significant: Chi-square method ($\chi^2 = 19.46$, $p < 0.01$) and the Kolmogorov-Smirnov method ($p < 0.01$). The correlation coefficient ($r = -0.85$, $p < 0.01$) also showed a statistically significant decreasing trend in the number of players from January to December.

In **Figure 1**, the expected distribution of the Belgian population per birthdate quartile (1990–1996) was plotted vs. this observed distribution of the 151 soccer players. The expected Belgian population was equally distributed per quartile (range 24.2–25.8).

## RAE and personality constructs

The highest mean scores and mean top 10 scores over the whole dataset were reached on personality constructs like self-confidence (mean 5.4, mean top 10 scores: 7.6) and winning mindset (mean 5.4, mean top 10 scores: 7.7) by the elite youth Belgian players (**Figure 2**). The lowest mean scores and lowest top 10 scores were reached for personality constructs like team orientation (mean 4.8, mean lowest 10 3) and self-development (mean 4.9, mean lowest 10 2.8) (**Figure 2**).

The median scores for personality constructs and the corresponding $p$-value for the first vs. last quartile are shown in **Table 1**. The only personality construct with a significantly higher median score for the players from quartile 4 (score 6) compared with quartile 1 (score 5), which was statistically significant ($p = 0.04$), was self-confidence. Players of the last quartile also had higher median scores for personal constructs such as concentration (6 vs. 5, $p = 0.34$) and winning mindset (5.2 vs. 5, $p = 0.23$) (**Table 1**).

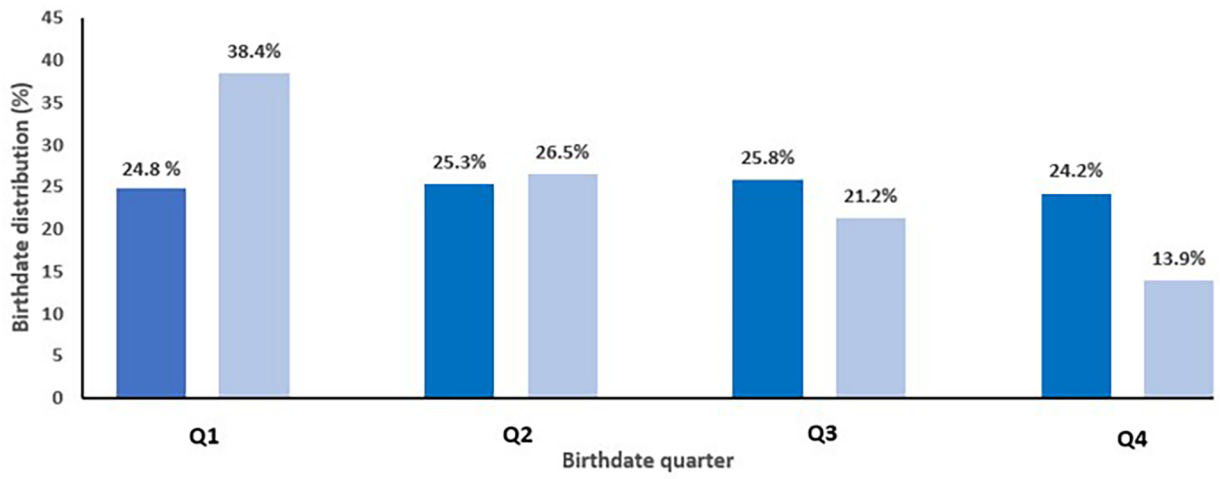


FIGURE 1
The expected distribution of the Belgian population per birthdate quarter (1990–1996) (dark blue bars) versus the observed distribution of soccer players per birthdate quarter (light blue bars) of the whole database.

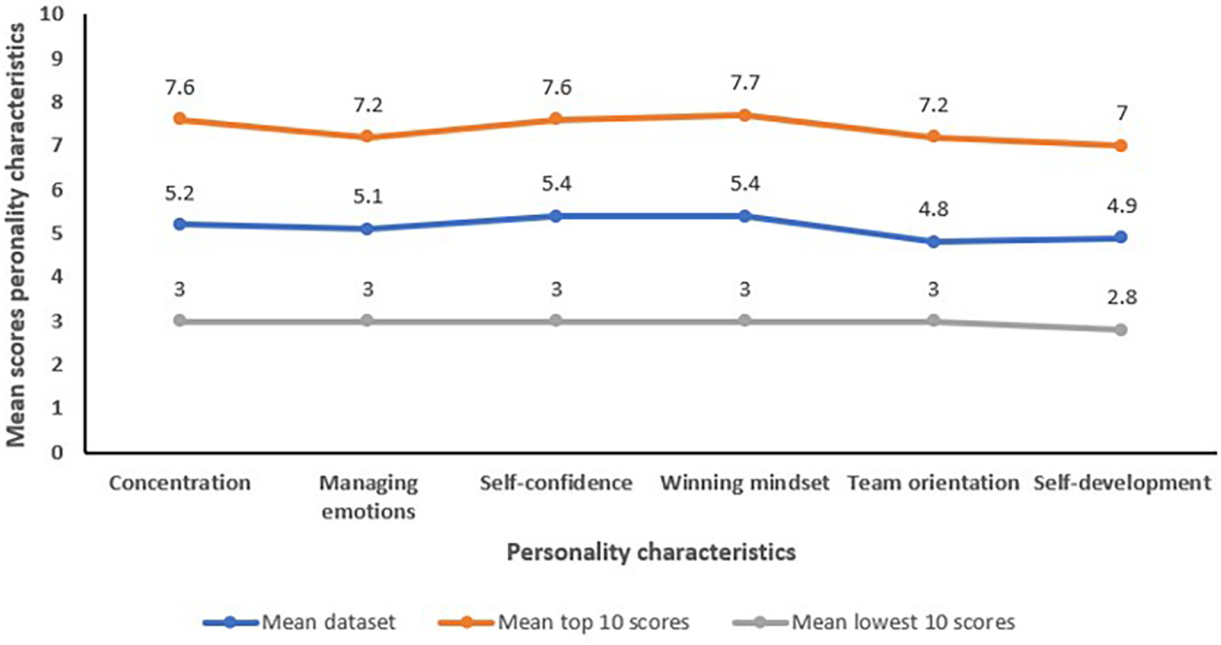


FIGURE 2
Combined data of the observations, questionnaires and interviews were used to score the youth soccer players on the six personality constructs (concentration, managing emotions, self-confidence, winning mindset, team orientation, self-development) on a nine-point standard scale. Mean scores for the whole database, for the top 10 highest scores and lowest scores for every personality construct are assessed.

Table 2 shows the median scores for personality constructs and the corresponding $p$-value for both semesters. There was a non-significant higher median in semester 2 (score 6) compared with semester 1 (score 5) for "self-confidence" ($p = 0.06$). This result was approaching statistical significance ($p = 0.06$). For the personality construct "team orientation", the median was significantly higher ($p = 0.03$) in semester 1 (score 5) compared with semester 2 (score 4).

## RAE and long-term career evolution

The mean FU of the study population was 8 years. Figure 3 shows the players' long-term playing level per quartile. 76.2% (16/21) of the players born in the last quartile were contracted as professional soccer players (abroad, Jupiler Pro League, or 1B). For the first quartile, only 46.6% of the players (27/58) had a similar professional status (Figure 3).

TABLE 1 Median scores of the players on personality constructs on a nine-point standard scale, based on observations, interviews and questionnaires pro birthdate quarter (Q) with consideration of statistical significance by comparing median scores of Q1 with median scores of Q4 (*p*-value).

| | *p*-value | Median score pro quarter | | | |
|---|---|---|---|---|---|
| | | (Q) Q1 | Q2 | Q3 | Q4 |
| | | *n* = 58 | *n* = 40 | *n* = 32 | *n* = 21 |
| Self-confidence | 0.04* | 5 | 5 | 5 | 6 |
| Winning mindset | 0.23 | 5 | 5 | 5 | 5.2 |
| Self-development | 0.45 | 5 | 5 | 5 | 5 |
| Managing emotions | 0.12 | 5 | 5 | 5 | 5 |
| Concentration | 0.34 | 5 | 5 | 5 | 6 |
| Team orientation | 0.41 | 5 | 5 | 5 | 4 |
| Total | **0.12** | **5** | **5** | **5** | **5.2** |

*$p < 0.05$ (statistically significance); Q, birthdate quarter.
The bold values provided are the mean scores and *p*-values of the players on the sum total of personality constructs pro birthdate quarter.

TABLE 2 Median scores of the players on personality constructs on a nine-point standard scale, based on observations, interviews and questionnaires pro semester (S) with consideration of statistical significance by comparing median scores of S1 (born between January and June) with median scores of S2 (born between July and December) (*p*-value).

| | *p*-value | Median score pro semester (S) | |
|---|---|---|---|
| | | S1 | S2 |
| | | *n* = 98 | *n* = 53 |
| Self-confidence | 0.06 | 5 | 6 |
| Winning mindset | 0.38 | 5 | 5 |
| Self-development | 0.31 | 5 | 4.5 |
| Managing emotions | 0.31 | 5 | 5 |
| Concentration | 0.19 | 5 | 5 |
| Team orientation | 0.03* | 5 | 4 |
| Total | **0.22** | **5** | **5** |

*$p < 0.05$ (statistically significance); S, semester.
The bold values provided are the mean scores and *p*-values of the players on the sum total of personality constructs pro semester.

Of the players born in the last quartile, compared with the players born in the first quartile, more players were signed as a professional soccer player abroad (Q4 47.6% vs. Q1 31.0%), as a professional soccer player in the first division Jupiler Pro League (Q4 19.0% vs. Q1 6.9%) and as a professional soccer player in the second division 1B (Q4 9.5% vs. Q1 8.6%) (**Figure 3**).

A non-significant higher number of players born in the first quartile ended their career or didn't find a club (11/58, 19.0%) later, compared with players born in the last quartile (3/21, 14.3%).

Of the 20 soccer players who had the highest total score on personality constructs, 13 players (65.0%) received a professional contract. This was in contrast with the 20 lowest scoring players, of which only 7 (35.0%) were professionals (**Figure 4**).

Of the 20 soccer players who had the lowest total score on the personality constructs, more (6/20, 30%) players finished their career or were not able to sign with a club, compared with the 20 soccer players who had the highest total score on the personality characteristics (0/20, 0%) (**Figure 4**). More positive scores on psychological constructs appears to scaffold one's later success in professional soccer.

## Multiple stepwise regression analysis

A multiple stepwise regression analysis was carried out to investigate which parameters are critical to predict professional future performance.

Birth date quarter, future professional level and the 6 personality constructs were implemented into forward stepwise multiple regression analysis. The aim would be to identify which parameters would predict professional success best and add independently the most in predicting future professional level (Multiple R) by taking out the covariation.

The results of the regression indicated that the model of predicting future professional level explained 37.3% of the variance and that the model was a significant predictor of future professional level [$F$ (8, 148) = 2.87; $p = 0.05$]. Self-confidence

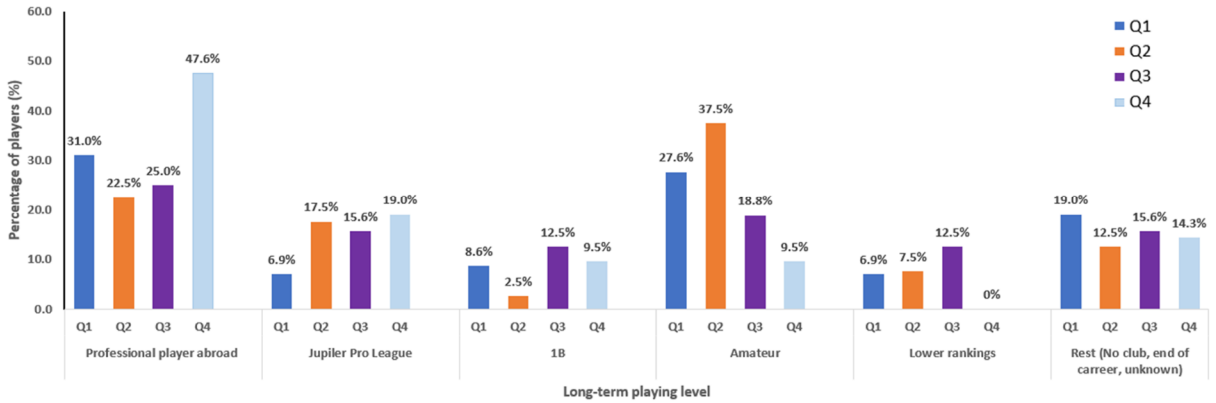


FIGURE 3
Evaluation of the long-term career development by assessment of the long-term playing level of the whole database per birthdate quarter (Q): players were categorized as professional player abroad, first division Jupiler Pro League, second division 1B, Amateur player, player in lower ranking and player who ended their career (rest).

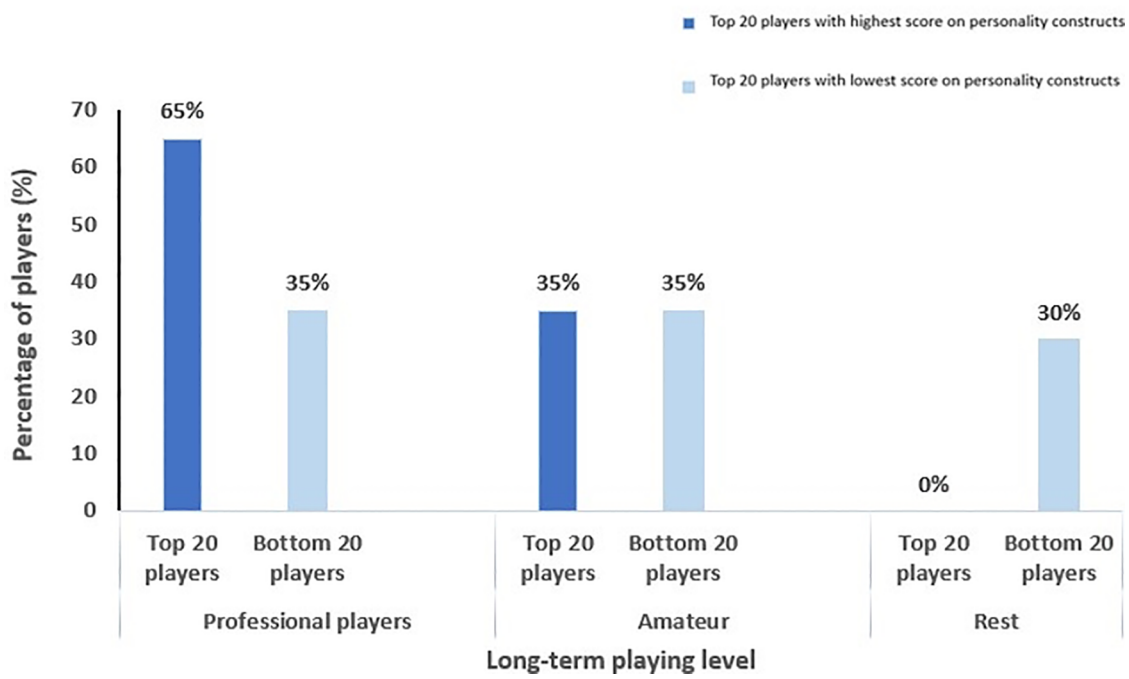


FIGURE 4
Correlation between long-term playing level and scores on personality constructs. The 20 players with the highest scores (dark blue bars) on personality constructs were compared with the 20 players with the lowest scores (light blue bars) on personality constructs.

contributed most to future professional level (regression coefficient 4.77; $p = 0.60$) comparing with the other 5 distinct personality constructs and birth date quarter (regression coefficient 0.10; $p = 0.43$). These predictors were not significant.

In case of restricting possible predictors for future professional performance to quarter and self-confidence, a correlation of 32.9% between future professional outcome, birth date quarter and self-confidence could be observed [$F$ (2, 148) = 8.98; $p < 0.05$]. Self-confidence contributed most to future professional level. While self-confidence contributed significantly to prediction of professional level (regression coefficient 0.397; $p = 0.12$), quarter did not (regression coefficient 0.148; $p = 0.27$).

In case of predicting future performance level, lonely based on birth date quarter in advance of late mature players; a correlation of 12.8% between both parameters could be observed [$F$ (1, 149) = 2.49; $p = 0.12$]; in which quarter was not significant.

On the other hand, by predicting future performance outcome, lonely based on self-confidence; a correlation of 31.7% can be identified [$F$ (1, 149); $p = 0.00007$] (Table 3). All the other factors contribute each independently less than 1% of R square change.

TABLE 3 Multiple stepwise regression analysis is presenting what each individual parameter adds independently in terms of predicting who attains professional level.

| | | | | 95% CI Regr. Coeff | | |
|---|---|---|---|---|---|---|
| Parameters | Mult. R (%) | R sq.(%) | Regr. coeff. | Low. 95% | Up. 95% | *p*-Val. |
| Self-Confidence | 31.70 | 10.10 | 0.24 | 0.13 | 0.36 | 0.00007 |
| Quarter | 12.80 | 1.60 | 0.08 | −0.02 | 0.17 | 0.12 |
| Total Characteristics | 10.30 | 1.10 | 0.04 | −0.02 | 0.11 | 0.21 |
| Semester | 10.0 | 1.0 | 0.03 | −0.02 | 0.07 | 0.22 |
| Winning mentality | 9.80 | 0.95 | 0.07 | −0.04 | 0.18 | 0.23 |
| Team orientation | 9.10 | 0.82 | −0.06 | −0.17 | 0.05 | 0.27 |
| Managing emotions | 8.30 | 0.68 | 0.06 | −0.06 | 0.18 | 0.31 |
| Concentration | 5.80 | 0.33 | −0.04 | −0.17 | 0.08 | 0.48 |
| Self-development | 1.80 | 0.03 | −0.01 | −0.12 | 0.1 | 0.82 |

Total characteristics implicate the sum of all the personality constructs together (Self-confidence, winning mentality, team orientation, managing emotions, concentration, self-development). Following the multiple stepwise regression analysis, self-confidence (Multiple R of 31.70%) contributes most concerning the prediction of future professional level.
Mult. R, Multiple R; R sq., R square; Regr. coeff., Regression coefficient; Low. 95%, Lower 95%; Up. 95%, Upper 95%; *p*-Val., *p*-Value.

So, following the multiple stepwise regression model; there is a co-linearity across personality characteristics and relative age effects, in which the personality characteristics of self-confidence contributes most (multiple $R = 31.7\%$, R square = 10.1%, $p = 0.00007$), concerning the prediction of future professional outcome.

## Discussion

The RAE is a well-researched phenomenon in soccer (19, 44–46). In childhood and adolescence, youth football players are categorized by chronological annual age groups, driven by the arbitrary "cut-off" or "selection" dates (5). Both, within sport and educational contexts, individuals are often divided into chronological age categories in an attempt to ensure fairness and equality. However, the chronological age gap of up to 12 months between players born early (January) and late (December) in the year leads to substantial variation in physical performance and finally biased talent selection decisions (6, 7, 9, 19). The 151 players in this study were grouped within categories according to typical Belgian domestic soccer season birthdate quartiles depending on their date of birth and expressed as a percentage of the sample population with a cut-off date of January 1st. The result of participation or selection bias because of maturity-related bias, specifically the overrepresentation of chronologically older soccer players within one age category, is called relative age effects (RAEs), which describe the (dis)advantages associated with being the relatively youngest or oldest within a particular age category (13). RAEs effect talent development systems and academies in a wide range of team and individual sports, e.g., ice hockey, soccer, swimming, and tennis, in both female and male categories from 4 years of age to adulthood (8, 11, 15, 45, 47). The age distribution of our study population showed a clear RAE for the overall dataset. Relative age and maturity selection bias can both confound academy soccer talent selection and development strategies (6, 48). Relatively old children within chronological annual age categories are more likely to be selected in talent development teams, with selection accompanied by additional training, and access to higher quality coaching with better opponents, likely leading to accumulated performance advantages (4, 6, 9, 19, 24).

As stated earlier, these early maturing players are often marked as possessing temporary, maturity-related advantages in anthropometric (e.g., stature and body mass) and physical fitness characteristics (e.g., power, strength, speed) (16, 18). These temporary advanced somatic characteristics are often perceived as dominant by talent scouts and coaches, because they typically characterize key tactical roles and playing positions (1, 2, 4). Subsequently, this can lead to a (sub)conscious reduction in selection opportunities or abandonment of relatively young players (6, 19).

So in consequence, the relatively young players, who may also be smaller and less physically developed, but who have equal technical and tactical ability, are underrepresented. As a consequence they are less likely to be selected for talent development systems and academies, and are finally more likely to withdraw early from sports (19). This biased selection during youth talent development programs in soccer academies limits a relatively young player's chances of succeeding later in their career transition to a professional player. Of the 20 soccer players who had the lowest total score on the personality constructs in our study, more players (30%) finished their career or were not able to sign with a club, compared with the 20 soccer players who had the highest total score on the personality characteristics (0%). The late-maturing players may suffer other consequences in academies as they are disadvantaged by lower selection quotas by scouts, which may lead to less competition experience and exposure to better opponents. This may cascade to lower motivation and less access and exposure to high-quality training. However, there is a ray of hope because recent RAE studies have found that by reducing RAE in talent development programs, there are benefits to these same players as they age. This suggests there are delayed benefits if late maturing players can be sustained within the talent development system (11).

Children continue to learn, mature and develop in all ways as they get older. Under existing youth systems, they are grouped according to their chronological age groups in educational and sports settings. The primary aim is to allow them to develop and compete with comparable individuals to ensure fairness and account for maturational differences and, as such, to give them all the same opportunity for sports participation and success in talent development (5). To set objective limitations and provide developmentally equitable competition, these chronological categories are bound by "cut-off" dates. In the Flemish educational and football system, pupils are organised into one-year age groups, using January 1 as the cut-off date. We remarked a nearly threefold overrepresentation for youth players born in the first quartile of the selection year as well as a clear underrepresentation of players born in the last quartile in our study. All this happens in spite of the fact that, maturational effects may result in large development inequalities between chronological and biological age (48). This is particularly true throughout puberty. However, in any given educational or sporting year-group, this chronological birthdate distribution has significant consequences for future successful performance by its consequential impact on talent selection and progression, known as the relative age effect (RAE) (6, 12, 49, 50).

Interestingly, previous research has illustrated how relatively younger players, who are selected for a talent development system, actually have in the long-term a greater chance of becoming a professional player than their initially relatively older opponents (11, 30). These observations have become encompassed in the "underdog hypothesis" (11, 37). Late-maturing players are more likely to be signed professionally and reach prestigious career during their professional development. Concerning the players' long-term playing level per quartile in our study, 76.2% of the players born in the last quartile were contracted as professional soccer players, in comparison with only 46.6% of the players with a similar professional status for the first quartile. This is because of multiple factors; for example they may benefit more from competitive play and trainings with their older opponents after selection, or it may be because of

their stronger psychological factors (2, 27, 37). Surely there are organizational and financial benefits for clubs if soccer academies can accurately and efficiently recruit and develop "home-grown" potential in their youth players (1, 51). Likewise clubs recognize that individually highly skilled players usually result in better team performance, and the route to more talented, highly skilled individual players is through effective youth academies and training. Research that provides greater insight into the causative processes and mechanisms of the RAE and personality structure, and therefore more effective talent identification, may lead to better future performance productivity and talented players for clubs (1, 2). From an economic perspective, it is often more cost effective for football clubs to buy undervalued players with initial lower market values. Lower market values may be initial assessed because of lower physical constructs. Clubs hope for higher performance and higher returns on investment based on player's perceived strong psychological profile. Therefore, assessing the actual and future values of possibly talented youth soccer players requires a multifactorial approach with physical, technical, tactical and psychological assessments amassed to assist talent identification and training profiles for each individual player.

This study showed that late-mature players have higher-value senior professional contracts in the long-term. Romann et al. revealed that late-mature players have higher market values over time as well and are undervalued in younger age groups (52). Our belief is that current as well as future players' real market values are based on both their physical and psychological characteristics and will, therefore, play an increasing role in talent recruitment, sports economics and talent development for clubs. Allof these factors dramatically impact sport development academies in their role as the primary entrance point for most professional talented players.

The first objective of this study was to identify the presence of a significant RAE in this cohort of selected Belgian elite youth players. The second objective was to assess the association between RAE and personality constructs by selected elite youth players. The third objective was to assess the association between the long-term career development of a senior soccer player and their initial personality factors.

Our results clearly show that the RAE is present for the whole database and each age category (**Figure 1**). Relative age distributions between quartiles for the whole database are shown in **Figure 1**.

In this cohort of 151 Belgian youth elite players, the magnitude of the RAE was a factor of 2.61 (OR: 2.61; 95%CI: 1.14–5.98, medium effect size) for the overall sample of youth players (Q1 = 38.4% vs. Q4 = 13.9%) (**Figure 1**). A significant uneven distribution was observed for each age group (1990–1996), with 31.2%–50.0% of players born in Q1 and 4.5%–21.9% in Q4. So, we saw a nearly threefold overrepresentation for youth players born in the first quartile of the selection year as well as a clear underrepresentation of players born in the last quartile. This typical distribution of the RAE of squads has also been reported in earlier studies (9, 16, 18). Our findings illustrate that for the entire cohort of 151 Belgian youth elite players, relatively old and more mature players (quartile 1) were 2.61 times more likely to be registered and participate in development elite programs compared to the quartile four relatively young and late-maturing players. These odds ratios of RAE were comparable with those determined prior in Belgian soccer academies.

We observed that selected players from the U16 to U19 age categories demonstrated equal anthropometric and fitness phenotypes. Only relatively young players with advanced normative growth and maturation, were selected to receive advanced coaching opportunities and education in training and competition.

Previously, a developmental systems model was used to explain the mechanisms of the RAE (25, 46, 49). Wattie et al. suggested that the RAE in sports is based on individual, task, and environmental constraints (46). These effects are augmented by a more favorable alignment between the characteristics of relatively old youth and the demands of their developmental environment. As an individual constraint, the physical maturation of an athlete is important. More physically mature individuals have greater chances to be selected by coaches and talent scouts and exhibit different levels of ability and potential (1, 2). This is an advantage for relatively old athletes because physical development, namely stature and body mass, follow chronological age. It should be noted that relatively young athletes who have matured early are also provided more opportunities to be selected because of their physical characteristics (6, 17, 24). Gender can be seen as another individual constraint. Although the RAE is also observed in female athletes, it has been founded to occur less consistently and with a smaller magnitude (12, 14). It is hypothesized that this smaller RAE could be caused by less required competition among female athletes to gain access to an elite team (8). Social pressures that encourage adolescents to conform to gender-based stereotypes perhaps discourage females from participating on a more competitive level, especially early-maturing females. This can result in a smaller RAE.

Although maturity-related factors are essential components of RAEs, they are also underpinned by other, more global factors, which can influence the developmental contexts of the players (7, 24, 46).

Task constraints are relevant factors and refer to sport type and level of competitive play (46, 53). Sports, where physical characteristics are important, are more likely to favor athletes with advanced physical development, which is a possible benefit to relatively old youth players. An increase in RAEs with increasing competition levels has been identified (14, 54, 55). The more players competing for a finite number of places on teams, the more likely that the characteristics of relatively old youth may appear to optimally align with environmental and task demands, and the stronger the size of the effect.

Environmental constraints refer to the popularity, categorizing of the sport, policies governing its play, and family influences (46). So, for example no systematic RAE has been noticed in American football, which possibly can be explained by the fact that some American football leagues use a sub-classification based not only on age but also on body mass. All those individual, task and environmental constraints should not be seen as separate entities, because they all interact.

However, as has been demonstrated elsewhere and as we have seen in this research, components of the RAE are multifactorial (2, 14, 25, 46, 49). Thus, the impact on psychological and cognitive parameters needs to be evaluated, as psychological factors are considered important by practitioners during the talent selection process (1, 2, 4). Although the development of physical performance is a crucial element of talent identification, all other areas of performance (technical, tactical, psychological, or cultural) should be considered as objective selection criteria necessary to properly evaluate a player's quality and long-term development to improve talent identification.

Within professional youth soccer academies, it is the objective to promote the physical and technical skill development as well as personality development of talented players, which reflects the belief that personality plays a crucial role in players' future success (2, 27). Psychological characteristics have elsewhere been integrated into models of talent identification and development as significant predictors of success in sports and general evaluation of players (12).

Musch and Grondin explain and integrate the psychological factors that underlie the RAE in greater depth through various social agents (12). The way in which these social agents (parents, coaches, and athletes) interpret mechanisms such as physical stature, maturity, and cognitive ability creates RAEs through various effects such as the Pygmalion, Galatea, and Matthew effects (12).

Children who are relatively old are more likely to be perceived as more talented by their peers, families, and coaches. Temporary, physical fitness, and anthropometric advantages afforded to older and more mature players are often the reason why relatively old players are considered more talented (19, 46). The Pygmalion effect refers to the perception that the greater the expectation placed on an individual, the greater the result that individual will attain. These environmental influences can lead to better performance.

The Galatea effect is comparable, but here the athletes' expectations of themselves enhance their willingness to perform (25). The Galatea effect is a second form of self-fulfilling prophecy, whereby once expectations are placed upon an individual, that individual typically acts congruently with those expectations.

A third psychological and sociological effect related to the RAE is the Matthew effect: individuals who start with an advantage are more likely to keep their advantage over time (25). Specifically, relatively old children have greater access to advantages than their relatively young peers.

The first purpose of this study was to examine if there is any relationship between the RAE and personality constructs in elite Belgian youth soccer players. Personality and psychological factors are important in sports because they may influence an athlete's performance subcomponents (such as technical, tactical, and physical skills), and eventually, success in competition and talent selection (1, 2, 4, 27). Understanding an athlete's psychological profile can be useful for designing both general psychological training and interventions specific to the sport, position, and role of the player on a team (1, 4, 27, 28, 43, 56). This theoretical framework can be used to further understand the RAEs and eventually used to create policies aimed at limiting the negative effect of relative age in soccer and creating more equal opportunities for all players. In our study, we have focused on self-confidence, winning mindset, self-development, managing emotions, concentration, and team orientation.

Results from this study show that the highest mean scores and mean top 10 scores over the whole dataset were reached on personality constructs like self-confidence and winning mindset by the elite youth Belgian players (**Figure 2**). The lowest mean scores and lowest top 10 scores were reached for personality characteristics like team orientation and self-development (**Figure 2**). Therefore, personality characteristics like self-confidence and a winning mindset are important values to qualify and be selected as elite youth soccer players.

Among young elite players self-confidence is paramount to their future success as a professional player. Level of self-confidence and RAE together account for approximately 32% of one's success at the professional level.

Within professional youth soccer academies, it is obviously important to promote physical and technical skill development as well as personality and psychological development of talented youth players, which reflects the stance that personality plays an important role in players' future success and development as senior professional players (57). Elsewhere psychological constructs and development have been integrated into models and procedures of talent identification and development. psychological constructs have also been identified "as significant predictors of success" in sports (32, 58). Thankfully because elite youth academies require clubs to focus on both psychological development and support of players, academies have started to include psychological constructs in their general evaluation of players (27). Therefore, in recent years scouting sheets assessing and evaluating technical and tactical skills have been revised to include and evaluate these psychological constructs. Youth elite academies ask their staff regularly to evaluate the players' psychological constructs and development. Previous research has confirmed that sport-specific self-report questionnaires revealed many different psychological constructs, ranging from motivational aspects (27) to self-regulation (22) or the use of coping strategies (59). Earlier studies concluded that self-regulation, resilience, commitment, and discipline had an important impact on player development and future success (60). Previous studies also stated that successful youth players scored better on psychological constructs like motivation, confidence, self-referential cognitions, and emotion by applying a questionnaire (35). Furthermore, strong psychological constructs were positively associated with current and future soccer performance and development (27, 35, 58). To our knowledge this is the first study using multiple regression to demonstrate the relative strength and importance of one's self-confidence level related to RAE.

In our cohort of elite youth players, the players born in the last quartile had the highest median score on self-confidence (6 vs. 5), which was statistically significant ($p = 0.04$) (**Table 1**). Players in the last quartile also had higher median scores for personal constructs such as concentration (6 vs. 5, $p = 0.34$) and winning

mindset (5.2 vs. 5, $p = 0.23$), but these results were not statistically significant (**Table 1**). There are multiple potential mechanisms to explain the observed relationship between RAE and personality constructs. Firstly, this is in line with the hypothesis that a possible cause of the RAE may be the Galatea effect. They have "beaten the odds" by being selected despite being relatively younger. Thus, the players born in the last quartile perceive themselves as more skilled. This results in a better work ethic which makes them better players and enhances their self-confidence (25). Galatea effects are a possible theory to explain the curious phenomenon of relatively young players excelling at professional levels. Possibly, relatively young or late-maturing children who manage in the end to be selected to elite youth teams also have increased self-expectations and motivation, which, after years of training, lead to professional success and development in youth academies (11, 22). So, we can connect the RAE with the Galatea effect.

Secondly, in case late-maturing players are to be selected for elite soccer academies, then they would take advantage to possess and/or develop more adaptive psychological attributes and skills. Concerning the underdog hypothesis, late maturing players may also need to develop more adaptive and efficient self-regulatory skills if they are to remain competitive within their age groups and would be selected for competitions and training. Former studies showed that delayed maturation was associated with greater self-regulation, planning, reflection, and evaluation. These more adaptive and efficient learning skills and psychological strength may help overcome some of the physical and functional disadvantages associated with later maturation (e.g., smaller stature, inferior strength, speed, power).

In the cohort of elite youth players, players born in the first semester scored better on team orientation, which was statistically significant ($p = 0.03$) (**Table 2**). Again, we observed that players born in the second semester, scored higher on self-confidence, compared with players of the first semester (6 vs. 5), in which the median scores were near statistical significance ($p = 0.06$) (**Table 2**). Concerning the observation that relatively old elite players scored better on team orientation, the Galatea effect could also play a crucial role. From a young age, relatively old players are more likely to get selected for an elite team. This causes them to see themselves as more competent. Galatea effects might provide a theory that explains long-term athletic attainment (25). Specifically, it is often stated that athletes are selected for elite teams based on physical maturity rather than skill (61). This would create false self-beliefs from relatively old and more mature athletes concerning their sports skills, which would cause the initiation of the Galatea effect. Next, as athletes are convinced of those expectations, they raise their self-expectations of abilities and behaviors that match self-expectations and motivation, affording continued success and selection in elite soccer academies (25). These new behaviors might include more diligent and frequent training sessions, which would suggest the Galatea effect. So, we can connect the RAE with the Galatea effect.

This effect is also enhanced by the Pygmalion effect, in which coaches and parents reinforce this competence. The Pygmalion effect refers to the inherent perception that the greater the expectation placed on an individual, the greater the result that the individual will attain in the end (25). Conversely, when lower expectations are placed upon individuals, outcomes will be inferior. Coaches set expectations on athletes and make selections and determinations of talent based on physical maturity (62–64) rather than multifactorial skill or potential. Therefore, Pygmalion effects falsely based on physical maturity might lead to higher expectations for relatively old and early-mature children, elucidating why relatively old players succeed. Pygmalion effects are typically initiated from power relationships, such as teacher-pupil or employer-employee. In sport, the most appropriate relationship to situate the Pygmalion effect is the coach-athlete relationship, which will explain unequal selections (25). In sports like soccer, coaches will have expectations for athletes; however, expectations based on false beliefs might perpetuate unfair advantage. These effects are even apparent after selection (25). Coaches often orchestrate practices in groups and interact with players during competitions and training, in which they treat players differently, possibly founded on inherent expectations. Consequently, youth soccer coaches offered high-expectancy players more reinforcement, while low-expectancy players received more general instructions. High-expectancy players are awarded more supplementary feedback, praise, and efficient instruction compared to low-expectancy players (25). Perceived competence is one of the characteristics related to peer leadership behavior. Players with peer leadership behaviors contribute to social cohesion and team efficacy (28).

Coaches and parents facilitate Pygmalion effects in soccer (25). Expectations of coaches and scouts might perpetuate or amplify RAEs that are initiated at earlier ages by parents and teachers. The impact of social agents on RAEs is crucial, more specifically the inherent effect of the Pygmalion and Galatea frameworks on RAEs. Possibly, if Pygmalion and Galatea effects of parents and coaches on players can be reduced, RAEs might also decrease, thereby helping to create a non-discriminatory soccer setting.

The existence of RAEs causes inequal distributions (5, 9, 19, 45). Fundamentally, asymmetric distributions are acceptable in soccer, but we believe they should be based on skill, talent, and potential rather than a birthdate, stature, or maturity. Social agents like parents and coaches have a strong impact on RAE by Galatea and Pygmalion effects. Nevertheless, it appears that social agents sometimes interpret physical maturity as talent, in terms of stature and body mass (63). Matthew, Pygmalion, and Galatea effects are intrinsically integrated and implemented by parents, coaches, and players as they relate to the RAE. Coach selections related to relative age would also be influenced by parental enrolment decisions (25). The influence of players on the RAE is determined due to Galatea effects, or the self-expectations that players possess, which might be higher for relatively older athletes. The higher expectation of players would be caused by the influence to which players indirectly are exposed by coaches and parents. Therefore, coaches and parents exert their influence and impact on RAEs indirectly through the self-expectations of players (25). For coaches, we also noted a clear reciprocal Pygmalion effect (25). Coaches tended to place

higher expectations on relatively old players, which might also reflect the RAEs. Therefore, when relatively old players fulfill these higher coach expectations, they complete the self-fulfilling prophecy, which in turn would cause coaches to further increase expectations of their players, hence a reciprocal process. Alternatively, a possible effect of coaches placing high expectations on relatively old team players is that parents also share these higher expectations. Therefore, parents might increase the self-fulfilling prophecy and RAEs by placing higher expectations on their relatively old children. It may be hypothesized that by eliminating Matthew effects and Pygmalion effects, RAEs could also be minimized, or at least influenced, but further research is necessary. By getting more information about the working mechanism of the Pygmalion and galatea effect, a deeper understanding of the impact of RAEs would be gained, which might lead to concrete proposals that could reduce RAEs in soccer and create equal opportunities for all participants.

Personality characteristics like self-development and managing emotions showed no difference between players born in the first or last quartile (**Table 1**). This can be explained by the selected cohort of elite youth soccer players, so by the fact that these players were already preselected. Elite youth soccer players are more likely to own better self-regulatory skills like self-development (22).

In case late-maturing players are to be selected for elite soccer academies, then they would take advantage to possess and/or develop more adaptive psychological attributes and skills (4, 22, 35). Self-regulation is the process whereby a player takes ownership of their development by establishing personal goals, controlling their feeling, engaging in action to achieve these goals, including self-initiated processes to convert mental abilities into physical skills in the learning process and by evaluating their progress (22, 29). Players who excel in self-regulating also approach tasks with a high level of effort and possess increased levels of self-efficacy in managing general task situations (29). Self-regulation has been a key personal construct in youth elite soccer to manage effective learning, develop future potential, and differentiate between successful and less successful future professional senior players (22). Players who excel in self-regulated learning have been shown to use effective planning to improve their daily performance, evaluate training outcomes, and reflect on their development processes if learning objectives and strategies have been achieved with consideration of strengths and weaknesses (22). Elite youth soccer players possess more adaptive self-regulation than non-elite players, suggesting that self-regulation contributes to successful professional development as an elite youth soccer player (22). Higher levels of self-reflection and effort were identified by elite youth players. They appeared more willing and efficient to invest effort into successful task execution and were capable of adapting their knowledge and actions in order to execute skills (22). Failure to manage self-regulated learning has been shown to negatively impact performance outcomes in soccer (38). Concerning the underdog hypothesis, later maturing players may also need to develop more adaptive and efficient self-regulatory skills if they are to remain competitive within their age groups and would be selected for competitions and training. Former studies showed that delayed maturation was associated with greater self-regulation, planning, reflection, and evaluation (11, 22, 30). It is important to note that in earlier studies no correlation has been identified between relative age, adaptive self-regulative learning, planning, reflection, evaluation, and managing emotions (37). That may be an explanation for why no differences in median scores were observed in this study for personality constructs like self-development and managing emotions (**Tables 1**, **2**). Rather, it can be suggested that relative age and maturity selection biases exist and operate independently in elite soccer academies (48).

In correlation with the underdog hypothesis, more adaptive engagement in self-regulated learning, in particular, self-evaluation and reflection were identified by late-maturing players (37). These more adaptive and efficient learning skills and psychological strength may help overcome some of the physical and functional disadvantages associated with later maturation (e.g., smaller stature, inferior strength, speed, power) (65). These late-maturing players may have an advantage because of a stronger psychological profile as a senior professional player, when maturity-associated differences in stature and function have attenuated or, in some cases, reversed. This psychological advantage will only be realized, however, if later maturing players are selected into and retained within the elite youth soccer academies to gain experience in qualitative competitions and training. An isolated more adaptive self-regulation profile, though desirable in the long-term development of elite youth soccer players, may not be sufficient to overcome the physical disadvantages associated with later maturation and/or guarantee progression to the most senior professional levels (22, 37). In support of this contention, equal scores in self-regulation were revealed in both relatively younger and older players (37). Thus, further strategies are required to ensure that talented, yet less mature, soccer academy players are not overlooked and excluded from elite youth soccer academies. It should be noted, however, that the players in the current study represent a highly select group of elite youth Belgian soccer players. Differences in relative age may exert greater influence upon self-regulated behavior by a broader cohort of different playing levels and younger ages. It is difficult to state whether later maturing players had always possessed more adaptive self-regulatory skills or if they developed as a result of the greater challenges that they had faced because of smaller physical stature. Thus, greater understanding is needed on how self-regulatory skills develop and the role that they play in the processes of selection and retention in elite youth soccer academies.

Finally, the current playing level of the study population as senior players was considered, approximately eight years after the initial data collection to assess which players reached the senior elite professional level. Results showed that players born in the last quartile were more successful compared to players of the first quartile (**Figure 3**). 76.2% of the players born in the last quarter were contracted as professional soccer players at the senior level, compared to 46.6% of the players born in the first quarter. More players of the last quarter received a professional contract as senior elite players at all the different professional playing levels: professional player abroad (Q4 47.6% vs. Q1 31.0%), first

division Jupiler Pro league (Q4 19.0% vs. Q1 6.9%), second division 1B (Q4 9.5% vs. Q1 8.6%) (**Figure 3**).

This is in line with the underdog hypothesis (11, 15). Since these players were selected for an elite team, the relatively young players had already "beaten the odds." Secondly, these relatively young players trained and competed with (at a given point in time) better players which was beneficial for their soccer education (15). Gibbs et al. also found that the average career duration was longer for relatively young players (11). Moreover, Ashworth and Heyndels found that players born late after the cut-off date earn systematically more (15).

These superior psychological constructs and successful long-term development of relative young players can be related and may be explained by the "underdog hypothesis", whereby being a relatively young player essentially facilitates long-term development by necessitating the player overcome the odds of the deep-rooted phenomenon of RAE, probably through being challenged by their older and more advanced peers (11, 30, 37). In the data collection, the achievement of senior professional status was noted; defined as signing a full-time professional contract for a minimum of one year. It is essential to better understand and gain more insights into why certain players might be more likely to be selected into an academy and to get more access to interesting competitions and training, and also why others might be more likely to successfully graduate and earn contracts as professional players. The current study showed not only further evidence of the RAE within a youth elite national soccer association but also provided evidence of the underdog hypothesis in national elite youth teams. This hypothesis only applied when relatively young athletes were selected for an elite team. It has elsewhere been detected in elite hockey players and national-level rugby and cricket players (11). Relatively young players are more likely to get higher value senior professional contracts, subsequently suggesting this may be due to the relatively young players developing superior psychological skills and technical expertise to compensate for their early physical disadvantage. It has been suggested that since they are selected to be elite players "against the odds", they are more talented through being challenged by their older and more advanced peers (11, 35, 37, 58, 60). Relatively young players that are selected to play on an elite team also have the advantage of receiving higher quality soccer education.

This underdog hypothesis may suggest a reversal of the distribution bias in the youth to senior transition as an elite soccer player. This is indicative of the potential advantage to those chronologically younger players within an elite youth soccer academy (11). Specifically, the underdog hypothesis suggests that to be competitive and be retained in elite youth soccer academies, relatively young and late maturing players must either be creative and possess and develop superior technical, tactical, and psychological skills. This comparatively greater challenge, which is experienced by relatively young and later maturing players, is thought to facilitate and encourage the development of these superior skills (11). While superior psychological and technical/tactical skills might be masked through childhood and adolescence, they become more obvious in late adolescence and early adulthood when age and/or physical maturity are attenuated or reversed (66). Late maturing players even benefit from spending a longer period in childhood and adolescence and so on in different developmental stages that are each optimized for specific learning and motor skill development to become more creative as a soccer player (67). However, the underdog hypothesis will only be realized during development in youth soccer academies if relatively young and later maturing youth are selected into or retained within the soccer development youth process, being exposed to the RAE (11, 37). The importance of being exposed to challenges and the need to possess adaptive psychological and behavioral skills have been long established as essential requisites for developing excellence in senior soccer levels (22, 68, 69). Young relative age may still cause an underdog advantage in attributes including motivation, decision making, resiliency, and/or technical and tactical ability.

Consequently, by eliminating the RAE in youth academy soccer academies, the potential "underdog" benefits for later birth quartiles, through consistently engaging with their older peers, may also be removed. Through competing against relatively old and often more mature players within their annual chronological age group, relatively young players have to develop certain technical proficiencies and/or tactical awareness to be able to counteract this physical bias against relatively old players (11, 22, 23, 30, 70, 71). So, more concrete, a physically larger and stronger player may be able to easily dispossess a physically smaller, weaker opponent as a result of their physical dominance, thus a smaller, weaker late-mature player must create a technical or tactical solution to reduce this advantage and to compete and develop successfully. These younger, smaller, late-mature players must overcome "a system that discriminates against them", by being more creative, skilled, and talented than their relatively larger counterparts to counteract their physical stature advantage (30, 70).

Furthermore, smaller and late-mature players which are often physically inferior throughout their youth development as a result of their younger age may have developed certain psychological constructs and skills, once primarily selected for youth academies towards adulthood, that allowed them to compete against their earlier mature opponents (2, 35). The underdog hypothesis demonstrated that the initial physical disadvantage may eventually contribute to the later psychological superiority when early differences in physical characteristics plateau towards the senior elite playing level (11, 37, 70). This is potentially through learning to "work and compete harder" and to be more creative, resulting in peer effects that facilitate resilience and improved motivation and self-confidence (22, 37). Thus, these psychological benefits and strong personality constructs like self-confidence, likely equip the chronologically relatively young players, or "underdogs", to overcome subsequent obstacles and opponents and succeed at a senior professional level (70, 71). Further support for the underdog hypothesis can be provided by the fact that selected relatively young players benefitted from competitive play with older peers by getting more match- and training- related experience, augmenting their

psychological advantage to compete successfully, compared to their earlier maturing equivalents.

The results also demonstrated that more players who were born in the first birthdate quarter, and examined eight years later, had not been retained by a club or had ended their career early (Q1 19.0% vs. Q4 14.3%) (**Figure 3**). The observation that more players of the first quarter ended early in their career may be associated with relatively lower scores on personality constructs such as motivation, winners' mentality, and self-confidence (**Tables 1**, **2**).

Comparing the top 20 players, who scored best on personality constructs, with the bottom 20 players, who scored worst on personality constructs, almost double the number the players in the top 20 (with strong personality constructs) received professional contracts as senior players (Top 20: 65% vs. bottom 20: 35%) (**Figure 4**). Even more players of the bottom 20 players (30%) ended their careers early compared with the top 20 players (0%), who scored best on personality constructs (**Figure 4**). So, an association between lack of superior personality constructs like motivation, self-confidence, and winners' mentality and lack of challenge during their development may determine early "drop-out" as a soccer player. We do not expect that more players with higher scores for personality constructs are still involved in professional soccer (39, 56).

## Limitations

One of the strengths of this study is that the study population is quite large. Furthermore, it is one of the first studies to examine the potential relationship between birthdate quartile and personality constructs in elite soccer. Different components (RAE, 5 personality construct s, and long-term career development) were investigated, incorporating new and innovative strategies to eliminate the RAE within talent identification and development processes in academy football to retain all potentially talented players during their development. Although this study demonstrates early promise, there are still a few limitations in this study.

As noted above, the study population is a sample of the best Belgian youth elite players, which can explain the limited differences between the quartiles (**Tables 1**, **2**). In addition, since the selection of players in the elite national youth team already happened retrospectively (before the data collection) this study can't test prospectively if the small differences in personality traits are one of the reasons for the RAE in this population. Also, the data originally were collected by the Royal Belgian Football Association for practice improvement, rather than for scientific research. In the psychologists' observations of the players during matches, a lot of factors were therefore not standardized, such as the strength of the opponent, the final score, and the number of minutes of play for a specific player.

Another limitation to be stated is that the Mann–Whitney *U* test can only compare two groups, which makes it difficult to see a trend over the four quartiles. Also, medians were compared instead of means. As a result, few differences were perceived between groups. Nevertheless, medians were most appropriate since linearity of the data could not be assumed.

Finally, the use of the questionnaires, should be discussed. According to guidelines stating that psychological constructs should be evaluated by combining players' self-rating and external expert rating in talent development and psychological analysis, the players performed a self-assessment by filling out the "Mental Potential Questionnaire" and the "Task & Ego Orientation in Sports Questionnaire" (TEOSQ) (40) in combination with observation during match play and an interview by external sports psychologists (27, 56). This self-assessment by the "Mental Potential Questionnaire" is nowadays replaced by valid questionnaires like the "Athletic Coping Skills Inventory" (43) and the "Big Five" (42). The Athletic Coping Skills Inventory ("ACSI") is a highly validated psychology assessment that measures an athlete's psychological coping skills in seven key areas coping with Adversity, coachability, concentration, confidence and achievement motivation, goal setting and mental preparation, peaking under pressure and freedom from worry (43).

The five-factor model of the "Big Five" is a dimensional representation of personality structure that has gained widespread acceptance among personality psychologists to analyze personality disorder scales. It validates five factors neuroticism, extraversion, openness, agreeableness, and conscientiousness. It helps to guide athletes who are interested in gaining more understanding and clarity around these mental skills that can impact performance. Athletes will answer a series of questions surrounding different performance psychology components (42).

We highly recommend the inclusion of valid sports psychologists' external ratings in addition to standardized self-report questionnaires (27). Within this perspective, there is a great potential in considering the psychological factors of players as predictors of current and future soccer performance and talent development and therefore clear recommendations and standards are needed to ensure an efficient and valid diagnostically assessment for clubs and associations within the youth talent development process (1, 27, 58). Nevertheless, beyond performance enhancement, there is much more to ethical, holistic talent development (60, 72, 73). We agree that in talent development, psychological constructs may also be important for promoting holistic athlete development to include players' well-being, the formation of positive relationships, and non-sporting enhancements to develop as strong individuals and athletes (73). In the context of the assessment of personality constructs for talent development, we recommend combining different sources of information like the players' self-assessment and the sport psychologists' external ratings (27, 74). Integrating self- and external ratings would be essential in developing a "multitrait-multimethod" approach (27, 75). A "multitrait-multimethod" approach for psychological constructs in talent identification and development involves the validation of different psychological characteristics by applying a variety of methods. For example, for measuring and validating "motivation" of a player, a standardized questionnaire could be used, and coaches and other

teammates can be asked to fill out standardized evaluation sheets with behavioral evaluations and interviews, behavioral observations by video analyses, or small-sided games by external experts can be added (72).

## Implications

This study shows that in the long run, relatively young soccer players who get selected for elite teams can turn their disadvantage into an advantage. The problem is that due to the RAE only a few relatively young players get the opportunity to show their worth (6, 9). The results of this study demonstrate that relatively young players also have a lot of potential to become successful soccer players. For this reason, scouts, coaches and the players themselves must acknowledge their strengths. By putting more emphasis on their strengths than on their weaknesses, relatively young players may be less discouraged and less likely to drop out before they reach a certain level of success (1, 27, 59). By frequent selection for national teams and successful clubs, youth players are exposed to better coaching and face better opponents; are implemented in higher and more prestigious competition levels, which would increase self-confidence and motivation. Many promising youth players have been overlooked by deselection in their early childhood because they suffered from a relative age and maturity disadvantage, which in the long-term will lower the overall multifactorial quality of professional sports teams, while youth players with proper technical and tactical attributes are being overlooked at an early age due to a lack of physical development and maturity that is only related to the period of the selection year in which they were born (6, 12, 19). The realization of possible solutions to the relative age (and maturity selection bias) is essential for efficient youth talent development processes. The awareness of staff and institutions is frequently inadequate to reduce this selection bias (44, 61). In their interactions with relatively young players, coaches should always concentrate on the long-term player's improvement in multifactorial constructs, rather than conducting unfair comparisons with the relatively old peers and focusing on short-term aims and isolated outcome factors like winning.

Different solutions to tackle relative age- and maturity-related bias have been proposed throughout the years, including changing and rotating the cut-off dates (44, 61), installing sport-specific cut-off dates, age-ordered numbered soccer shirts (76), birthday banding, the bio-banding method, whereby players are grouped according to their maturation status (3, 10, 77–82). Despite the relative success of some of these methods to reduce RAE (i.e., birthday and bio-banding) and maturity selection bias (i.e., bio-banding), some proposed remedies are difficult to implement in the daily structure of training programs and game formats. The recently proposed reallocation method showed to remove evidence of the relative age effect of players when compared to their distribution before reallocation and reduced the between-player variation in maturity, anthropometric and physical characteristics when compared to chronologically categorized playing ages (16, 18). It may be hypothesized that by eliminating Matthew effects and Pygmalion effects, RAEs could also be minimized, or at least influenced, but further research is necessary. It could be interesting for future research to investigate if RAEs could be reduced by using the reallocation method in our study population.

Awareness about the existence and possible consequences of the RAE in soccer settings is essential during the identification and development of youth soccer players and should be analyzed carefully in all their facets to minimize the loss of potential talent in the long-term and for the best development of all players on equal terms (9, 19, 44). It is unclear whether the avoidance of early or frequent deselection as a youth player within a talent pathway is beneficial for achieving long-term expertise, because of the underdog hypothesis (11, 37, 70). The long-term purpose of a youth soccer academy should be to identify and then develop talented youth soccer players towards strong multifactorial future performance abilities, in which attention should rather concentrate on the long-term course of multifactorial development, rather than focusing on current isolated performance abilities like physical characteristics (1, 2, 27, 35). In this study, a reversal of the distribution bias in the youth to senior transition in the context of development to a professional player was observed, indicative of the potential advantage and abilities of those chronologically relatively young players. An interesting issue of this current study is that by eliminating the RAE in academy youth soccer the potential benefits created by the underdog hypothesis for relatively young players, through consistently engaging with their older peers, may also be removed. By playing against relatively old, more mature players within their chronological age group, relatively young or late mature players have to develop certain technical skills and tactical awareness to be able to counteract this bias based on lower physical characteristics (5, 11, 30, 70, 71). The relatively old and more mature player with stronger physical characteristics may be able to easily counteract a relatively young player, which is smaller and less strong as a result of their physical dominance, thus relatively young or late mature players must create a technical or tactical solution to reduce this advantage. Relatively young players must overcome a system that discriminates against them, by being more talented and creative than their relatively large counterparts to counteract their physical stature and body mass advantage. Therefore, this underdog hypothesis, where the initial physical disadvantage may eventually contribute to the later multifactorial superiority when early differences in size equalize towards development as a professional senior player (11, 30, 37, 70). This is potentially through learning to compete in difficult "unequal" situations, resulting in peer effects that facilitate self-confidence, resilience, and improved motivation. Thus, these psychological values and benefits likely advantage the chronologically younger players, or "underdogs", to overcome subsequent obstacles during their development and succeed at the senior professional level by receiving professional contracts (71). Therefore, the main issue would be how youth soccer academies get the "best of both worlds" concerning moderating the RAE whilst also gaining the

benefits and values of the underdog hypothesis. Current strategies to create an occasional underdog hypothesis in youth player academy development appear still unexplored (11, 37). This underdog effect could be occasionally created in training formats of youth academy settings by "playing-up" a chronological age group to facilitate more efficient and multifactorial development of relatively old players by creating an "underdog effect" in an older age group. Furthermore, these inventions may also reduce the widely reported high drop-out rates amongst late mature players (19) by providing more selection opportunities for relatively young and late mature players into an elite youth soccer academy at an early age. Even by "playing-down" a chronological age group, it may also offer a more suitable developmental setting for late mature players whilst they compete with their chronologically older peers, whilst also providing a more challenging environment for early birthdate quartiles in a younger age group. Therefore, occasionally implementing in training formats of youth soccer academies a "flexible chronological approach" to players, offers relatively old and relatively young players the opportunity to play up and play down an annual age group respectively, as opposed to fixed chronological bandings. This transient rotating system of "flexible approach" may also be applied in the recently presented maturity-related system of reallocated groups to create an "underdog effect".

The Royal Belgian Football Association is working with "future youth teams", that are made up from late mature players. In this way, late maturing talented Belgian players have the opportunity to benefit from the high-quality training and competition in order to combat the problems of maturity and growth. Occasionally these teams are implemented in training and competitions formats with older players as "flexible chronological approach".

Because of the RAE, higher drop-out rates are observed among relatively young and late-mature players (6, 9, 19). However, the results of this study show that relatively young players have more opportunities to reach a status as professional senior players in the long term.

In the context of the RAE, it is essential to acknowledge the limited opportunities for relatively young and late mature players to be selected in an elite youth soccer academy, thus emphasizing the dual responsibility and importance of soccer academy staff and scouts to be aware of the RAE in youth soccer academies in order to prevent loss of talent by early drop-out and to develop youth players holistically/ multiskilled to a professional talented senior soccer player.

The least mature players and relatively young players within an age group may have a greater need to possess superior technical/ tactical or psycho-behavioral skills than those relatively old counterparts. Because it is essential to highlight the potential benefits of later maturation in soccer, it's equally important to consider any possible disadvantages associated with early maturity. Due to the pressure to succeed and avoid being released, early maturing players may be encouraged only to rely on their stronger physical and functional advantages at the expense of their psychological and technical/tactical development (3, 4, 7). In the context of the transient nature of physical and functional advantages, early maturing players will also be unable to rely upon these physical attributes at the adult level during their development as youth soccer elite players. Therefore, youth soccer academies need to create multifactorial learning environments that encourage early maturing players to develop more adaptive creative skill sets (technical, tactical, psychological) and not only rely on their physicality. Recently proposed strategies such as the reallocation method (16, 18) future teams and bio-banding (10, 77), in which players are periodically grouped by maturity status rather than chronological age, will expose early maturing players to a greater challenge and to provide the same learning conditions and creativity that late maturing players experience regularly in chronologically based groups. In case early mature players compete in reallocated or bio-banded formats, they are less able to rely on their physical and functional qualities and are forced to use their technical, tactical, and psychological skills (3, 10, 16, 18, 83).

Sports psychologists can use their expertise to support early maturing players in such contexts by improving their psychological provision by evaluating their psychological assessment, teaching early maturing players how to create self-confidence and more adaptive self-regulatory skills to optimize their physical, psychological, technical, and tactical development (4, 27, 56). By limiting maturity-associated variation in physical characteristics like stature and body mass, bio-banding and reallocation may give late maturing players greater opportunity to use and demonstrate their technical, physical, and psychological attributes (3, 10, 16, 18, 83). Moreover, maturity-related grouping encourages a less physical and more technical and tactical style of play and will develop more multifactorial skilled and talented youth elite players in soccer academies. Maturity-related grouping strategies will reveal more technical-skilled soccer with more passing and dribbling in the maturity-matched format and will create youth soccer players with stronger personality constructs, that are essential to reach professional status in the long term (10, 37, 83). Academy soccer staff like coaches and scouts need to be aware of the RAE which is implemented in youth soccer academies by selection procedures and need to give more attention and relevance to psychological strength when evaluating player performance without being biased by maturity-associated characteristics (4, 27, 35). The RBFA puts a lot of effort into education and awareness about the RAE by coaches and scouts.

The Union of European Football Associations (UEFA) Financial Fair Play regulation states that all European professional soccer clubs are to operate and manage youth soccer development within their financial means (51). Because of the importance to develop "home-grown" youth talent to compete at professional senior level soccer and reduce club financial outgoings on imported talented players, there are a need for domestic professional soccer clubs to install ongoing talent (de) selection strategies that are free from (sub)conscious, transient, maturity related selection bias to prevent early drop-out of talented late mature players who have more opportunities to develop as a professional senior player. Another strategy in case

of interesting transfers may be to focus as youth soccer academy on talented late mature or relatively young players with initial lower financial value on the transfer market because of inferior physical characteristics, but who have more opportunities to develop as a professional senior player on the long-term because of their stronger technical, tactical and psychological skills. Therefore, good knowledge, guidelines, and awareness of the RAE and holistic characteristics of potential talented relatively young youth soccer players is essential for recruitment practitioners to reduce over-selection of early-maturing players and recruit "talented", multi-skilled relatively young players to create a bigger talent pool for elite youth soccer academies (1, 2, 4, 27, 35, 44, 58).

To successfully implement the diagnostic psychological assessments and interventions for potential talented youth players, we believe that additional support from experts in the field of sports psychology should be provided to clubs, elite youth soccer academies, and coaches. On the level of soccer formats in clubs and national associations, coach and scouting education programs could embed basic psychological diagnostic and interventional assessments within the standard curriculum to get some more skills around the development of personality characteristics in youth soccer players (1, 27, 32, 35, 58, 62, 73). To provide evidence-based insights into the correct and efficient psychological diagnostic principles, quality criteria, and potential interventions, in line with licensing requirements, cooperation with sports psychologists for clubs and soccer associations would be valuable. A lot of elite youth soccer academies consult sports psychologists to support the players and coaches in implementing the psychological assessments and goals set for their players' personality and well-being as well as efficient psychological skill development, especially for early mature players (27). Sports psychologists should not only offer psychological diagnostic assessments and interventions in talented youth development programs but also support staff and players to improve daily communication and functional performance in match and training formats. Licensed sports psychologists can help in relating relevant personality characteristics to theory-based psychological constructs and ensure an efficient diagnostical assessment of youth players. Sports psychologists belong to the staff of national youth soccer teams in Belgium, in order to support the psychological skill development of all elite youth players and improve functional performances in both match and training formats. Secondly, sports psychologists can support coaches' assessments in daily communication with players in training formats by providing feedback on the psychological intervention process of player development and evaluating results (27, 39, 57). Concerning the long-term development of youth academy players, applying a multitrait-multimethod approach and repeated measurements by the combination of questionnaires, interviews, and observations can provide the basis for an integrated, individual, long-term development plan for the players (27, 39). Through evidence-based diagnostic assessments and theory-based specific interventions for early- and late-mature players, sports psychologists should help develop the players' psychological skills according to their individual needs based on the RAE and diagnostic assessments (84). By awareness about the importance of personality characteristics in the development of youth elite soccer players, educating and supporting coaches in psychological diagnostic assessments, and intensive cooperation with sports psychologists, higher quality standards concerning psychological diagnostics and interventions in youth talent development programs could be reached. Consequently, improved and evidence-based diagnostic assessments and personal intervention programs for the psychological characteristics of talented players can, in turn, result in the better long-term performance of elite youth soccer players, which is beneficial for all stakeholders in talent development formats (1, 27, 35, 58, 60, 73, 84).

## Future directions for research

Concerning future research, it may be interesting to perform a longitudinal prospective study with a more extensive cohort of youth soccer players of different age categories and from different playing levels, before they are selected for any elite soccer team. This study format would explore in greater depth the association between personality characteristics and RAE because of Pygmalion, Galatea, and Matthew effects by the inclusion of psychological assessment of late mature or relatively young youth soccer players who eventually would not be selected in elite youth soccer academies and would drop out on the long-term.

Moreover, it would also be interesting to observe whether personality constructs change throughout an elite youth player's career due to his experience and holistic development as a player.

Further, future research can be performed to get some more insight into differences and progression in personality constructs between youth soccer players in more maturity-related grouping strategies like the reallocation method or bio-banding. It would also be interesting to observe if coaches nowadays take care of psychological constructs and mental well-being of their players.

Finally, it would be intriguing to observe if specific personal intervention programs for psychological constructs of talented elite youth soccer players, based on their psychological diagnostic assessment, would improve their opportunities to reach a senior professional status in the long term.

## Conclusion

Academy soccer players' development and talent identification settings are multifaceted and complex. Both require soccer practitioners to make informed judgements and evaluations relating to players' physical, technical, tactical, and psychological characteristics, which have been associated with greater development and performance outcomes as elite youth players and in their successful transition from youth academy level to senior professional status. Relative age and maturity-related selection bias have been offered as causal factors for the overrepresentation of players who are either relatively old and/or early maturing. This study demonstrated a clear RAE in a group

of 151 male elite Belgian youth soccer players. Early maturing players are often characterized as possessing temporary, maturity-related enhancements in anthropometric and physical fitness characteristics, consequently, they are often perceived as "more talented" by soccer practitioners. Relatively young players must overcome this selection bias, by being more talented and creative than their relatively large counterparts to counteract their physical advantage. Results of the study showed that once they reach adulthood, because of being creative and diverse with good technical and tactical skills, they also may have developed stronger psychological constructs like self-confidence and a winners' mentality that previously allowed them to compete. Relatively old players scored better on personality constructs like team orientation. The association between personality characteristics and RAE can also be explained by the Pygmalion, Galatea, and Matthew effects. The underdog hypothesis, where the initial physical disadvantage may eventually contribute to the later multifactorial superiority, provides relatively young players with more opportunities for successful development towards a professional senior player status, as they more frequently sign professionally as a relatively young player. Therefore, strategies to counteract the RAE are essential, to prevent early drop-out of late maturers and often more talented players with more opportunities to reach professional status.

However, underdog effects cannot be ignored whilst considering the socio-environmental dynamics when incorporating new and innovative strategies to eliminate the RAE within talent identification and development processes in academy soccer. Thus, it is suggested that soccer recruitment practitioners should act with caution when creating strategies to eliminate the RAE by eliminating the Galatea and Matthew effects, as doing so may also eradicate the underdog hypothesis. Therefore, occasionally implementing a "flexible chronological approach" in training formats of youth soccer academies by offering relatively old and relatively young players the opportunity to play up and play down a chronological or maturity-based age group respectively, as opposed to fixed chronological bandings, may help to counteract the underdog hypothesis.

Creating more awareness about the importance of personality constructs in the future development of youth elite soccer players, educating and supporting coaches in psychological diagnostic assessments and intensive cooperation with sports psychologists, may result in higher quality standards concerning psychological diagnostics and more specific interventions in youth talent development programs.

However, further research into the proposed solutions for the RAE, like maturity-related grouping as the reallocation method, and influences on the development of personality constructs, is required, to ensure there is a continued emphasis on creating the right environment for every player to develop to their full potential in elite youth soccer academies, taking into account side effects like the underdog hypothesis.

## Data availability statement

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

## Author contributions

WH initiated and supervised the research from the very beginning. Specifically, the aim of this work is to create more awareness of the importance of personality constructs in the future development of youth elite soccer players. SB performed the analytic calculations, numerical simulations and drafted the manuscript. KP was also involved from the start, contributed to all stages of the study, data collection and the interpretation of the results. WH, DM, JS and KP revised preliminary drafts as well as the final version. All authors contributed to the article and approved the submitted version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

1. Larkin P, O'Connor D. Talent identification and recruitment in youth soccer: recruiter's perceptions of the key attributes for player recruitment. *PLoS One*. (2017) 12(4):e0175716. doi: 10.1371/journal.pone.0175716

2. Sarmento H, Anguera MT, Pereira A, Araújo D. Talent identification and development in male football: a systematic review. *Sports Med*. (2018) 48(4):907–31. doi: 10.1007/s40279-017-0851-7

3. Towlson C, MacMaster C, Gonçalves B, Sampaio J, Toner J, MacFarlane N, et al. The effect of bio-banding on physical and psychological indicators of talent identification in academy soccer players. *Sci Med Footb*. (2021) 5(4):280–92. doi: 10.1080/24733938.2020.1862419

4. Towlson C, Cope E, Perry JL, Court D, Levett N. Practitioners' multi-disciplinary perspectives of soccer talent according to phase of development and playing position. *Int J Sports Sci Coach*. (2019) 14(4):528–40. doi: 10.1177/1747954119845061

5. Cobley S, Baker J, Wattie N, McKenna J. Annual age-grouping and athlete development. *Sports Med*. (2009) 39(3):235–56. doi: 10.2165/00007256-200939030-00005

6. Hill M, Scott S, Malina RM, McGee D, Cumming SP. Relative age and maturation selection biases in academy football. *J Sports Sci*. (2020) 38(11–12):1359–67. doi: 10.1080/02640414.2019.1649524

7. Parr J, Winwood K, Hodson-Tole E, Deconinck FJA, Hill JP, Teunissen JW, et al. The main and interactive effects of biological maturity and relative age on physical performance in elite youth soccer players. *J Sports Med*. (2020) 2020:1–11. doi: 10.1155/2020/1957636

8. Vincent J, Glamser FD. Gender differences in the relative age effect among US Olympic development program youth soccer players. *J Sports Sci*. (2006) 24 (4):405–13. doi: 10.1080/02640410500244655

9. Helsen WF, van Winckel J, Williams AM. The relative age effect in youth soccer across Europe. *J Sports Sci*. (2005) 23(6):629–36. doi: 10.1080/02640410400021310

10. Abbott W, Williams S, Brickley G, Smeeton NJ. Effects of bio-banding upon physical and technical performance during soccer competition: a preliminary analysis. *Sports (Basel)*. (2019) 7(8):193. doi: 10.3390/sports7080193

11. Gibbs BG, Jarvis JA, Dufur MJ. 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*. (2012) 47(5):644–9. doi: 10.1177/1012690211414343

12. Musch J, Grondin S. Unequal competition as an impediment to personal development: a review of the relative age effect in sport. *Dev Rev*. (2001) 21 (2):147–67. doi: 10.1006/drev.2000.0516

13. Barnsley RH, Thompson AH. Birthdate and success in minor hockey: the key to the NHL. *Can J Behav Sci*. (1988) 20(2):167–76. doi: 10.1037/h0079927

14. Jackson RC, Comber G. Hill on a mountaintop: a longitudinal and cross-sectional analysis of the relative age effect in competitive youth football. *J Sports Sci*. (2020) 38(11–12):1352–8. doi: 10.1080/02640414.2019.1706830

15. Ashworth J, Heyndels B. Selection bias and peer effects in team sports. *J Sports Econom*. (2007) 8(4):355–77. doi: 10.1177/1527002506287695

16. Bolckmans S, Starkes JL, Towlson C, Barnes C, Parkin G, Helsen WF. Leveling the playing field: a new proposed method to address relative age- and maturity-related bias in UK male academy soccer players. *Front Sports Act Living*. (2022) 4:847438. doi: 10.3389/fspor.2022.847438

17. Towlson C, Cobley S, Parkin G, Lovell R. When does the influence of maturation on anthropometric and physical fitness characteristics increase and subside? *Scand J Med Sci Sports*. (2018) 28(8):1946–55. doi: 10.1111/sms.13198

18. Helsen WF, Thomis M, Starkes JL, Vrijens S, Ooms G, MacMaster C, et al. Leveling the playing field: a new proposed method to address relative age- and maturity-related bias in soccer. *Front Sports Act Living*. (2021) 3:635379. doi: 10.3389/fspor.2021.635379

19. Helsen WF, Starkes JL, Van Winckel J. The influence of relative age on success and dropout in male soccer players. *Am J Hum Biol*. (1998) 10(6):791–8. doi: 10.1002/(SICI)1520-6300(1998)10:6<791::AID-AJHB10>3.0.CO;2-1

20. Boccia G, Brustio PR, Rinaldi R, Romagnoli R, Cardinale M, Piacentini MF. Junior to senior transition pathway in Italian Football: the rocky road to the top is not determined by youth national team's selections. *PLoS One*. (2023) 18(7): e0288594. doi: 10.1371/journal.pone.0288594

21. Brustio PR, Modena R, Boccia G, Vogliazzo M, Kelly AL. Youth-to-senior transition in women's and girls' football: towards a better understanding of relative age effects and gender-specific considerations. *PLoS One*. (2023) 18(5):e0283781. doi: 10.1371/journal.pone.0283781

22. Toering TT, Elferink-Gemser MT, Jordet G, Visscher C. Self-regulation and performance level of elite and non-elite youth soccer players. *J Sports Sci*. (2009) 27 (14):1509–17. doi: 10.1080/02640410903369919

23. Schorer J, Cobley SP, Brautigam H, Loffing F, Hütter S, Büsch D, et al. Developmental contexts, depth of competition and relative age effects in sport: a database analysis and a quasi- experiment. *Psychol Test Assess Model*. (2015) 57 (1):123–43. ISSN: 2190-0507

24. Romann M, Rüeger E, Hintermann M, Kern R, Faude O. Origins of relative age effects in youth football-A nationwide analysis. *Front Sports Act Living*. (2020) 2:591072. doi: 10.3389/fspor.2020.591072

25. Hancock DJ, Adler AL, Côté J. A proposed theoretical model to explain relative age effects in sport. *Eur J Sport Sci*. (2013) 13(6):630–7. doi: 10.1080/17461391.2013.775352

26. Barnsley RH. Birthdate and performance: the relative age effect. *Conference paper Canadian Society for the study of education*; Windsor, Ontario (1988). p. 1–15.

27. Musculus L, Lobinger BH. Psychological characteristics in talented soccer players - recommendations on how to improve coaches' assessment. *Front Psychol*. (2018) 9:41. doi: 10.3389/fpsyg.2018.00041

28. Price MS, Weiss MR. Peer leadership in sport: relationships among personal characteristics, leader behaviors, and team outcomes. *J Appl Sport Psychol*. (2011) 23(1):49–64. doi: 10.1080/10413200.2010.520300

29. Zimmerman BJ. Development and adaptation of expertise: the role of self-regulatory processes and beliefs. In: Ericsson KA, Charness N, Feltovich PJ, Hoffman RR, editors. *The Cambridge handbook of expertise and expert performance*. Cambridge: Cambridge University Press (2006). p. 705–22.

30. McCarthy N, Collins D, Court D. Start hard, finish better: further evidence for the reversal of the RAE advantage. *J Sports Sci*. (2016) 34(15):1461–5. doi: 10.1080/02640414.2015.1119297

31. Zuber C, Zibung M, Conzelmann A. Holistic patterns as an instrument for predicting the performance of promising young soccer players – A 3-years longitudinal study. *Front Psychol*. (2016) 7:1088. doi: 10.3389/fpsyg.2016.01088

32. Reilly T, Williams AM, Nevill A, Franks A. A multidisciplinary approach to talent identification in soccer. *J Sports Sci*. (2000) 18(9):695–702. doi: 10.1080/02640410050120078

33. Kavussanu M, Ntoumanis N. Participation in sport and moral functioning: does ego orientation mediate their relationship? *J Sport Exerc Psychol*. (2003) 25(4):501–18. doi: 10.1123/jsep.25.4.501

34. Huijgen BCH, Elferink-Gemser MT, Lemmink KAPM, Visscher C. Multidimensional performance characteristics in selected and deselected talented soccer players. *Eur J Sport Sci*. (2014) 14(1):2–10. doi: 10.1080/17461391.2012.725102

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

36. Murr D, Raabe J, Höner O. The prognostic value of physiological and physical characteristics in youth soccer: a systematic review. *Eur J Sport Sci*. (2018) 18(1):62–74. doi: 10.1080/17461391.2017.1386719

37. Cumming SP, Searle C, Hemsley JK, Haswell F, Edwards H, Scott S, et al. Biological maturation, relative age and self-regulation in male professional academy soccer players: a test of the underdog hypothesis. *Psychol Sport Exerc*. (2018) 39:147–53. doi: 10.1016/j.psychsport.2018.08.007

38. Kitsantas A, Zimmerman BJ. Comparing self-regulatory processes among novice, non-expert, and expert volleyball players: a microanalytic study. *J Appl Sport Psychol*. (2002) 14(2):91–105. doi: 10.1080/10413200252907761

39. Thelwell RC, Greenlees IA, Weston NJV. Using psychological skills training to develop soccer performance. *J Appl Sport Psychol*. (2006) 18(3):254–70. doi: 10.1080/10413200600830323

40. Duda JL. Relationship between task and ego orientation and the perceived purpose of sport among high school athletes. *J Sport Exerc Psychol*. (1989) 11 (3):318–35. doi: 10.1123/jsep.11.3.318

41. Urquhart C, Light A, Thomas R, Barker A, Yeoman A, Cooper J, et al. Critical incident technique and explicitation interviewing in studies of information behavior. *Libr Inf Sci Res*. (2003) 25(1):63–88. doi: 10.1016/S0740-8188(02)00166-4

42. McCrae RR, Costa PT. A contemplated revision of the NEO five-factor inventory. *Pers Individ Dif*. (2004) 36(3):587–96. doi: 10.1016/S0191-8869(03)00118-1

43. Smith RE, Schutz RW, Smoll FL, Ptacek JT. Development and validation of a multidimensional measure of sport-specific psychological skills: the athletic coping skills inventory-28. *J Sport Exerc Psychol*. (1995) 17(4):379–98. doi: 10.1123/jsep.17.4.379

44. Helsen WF, Baker J, Michiels S, Schorer J, Van Winckel J, Williams AM. The relative age effect in European professional soccer: did ten years of research make any difference? *J Sports Sci*. (2012) 30(15):1665–71. doi: 10.1080/02640414.2012.721929

45. Musch J, Hay R. The relative age effect in soccer: cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociol Sport J*. (1999) 16(1):54–64. doi: 10.1123/ssj.16.1.54

46. Wattie N, Schorer J, Baker J. The relative age effect in sport: a developmental systems model. *Sports Med*. (2015) 45(1):83–94. doi: 10.1007/s40279-014-0248-9

47. Grondin S. *Influence du trimestre de naissance sur l'acces à la participation au hockey et au volley-ball [microforme]* [*Thèse (M.Sc.)*]. Université de Sherbrooke (1982).

48. Towlson C, MacMaster C, Parr J, Cumming S. One of these things is not like the other: time to differentiate between relative age and biological maturity selection biases in soccer? *Sci Med Footb*. (2021) 6(3):273–6. doi: 10.1080/24733938.2021.1946133

49. Pierson K, Addona V, Yates P. A behavioural dynamic model of the relative age effect. *J Sports Sci*. (2014) 32(8):776–84. doi: 10.1080/02640414.2013.855804

50. Møllerløkken NE, Loràs H, Pedersen AV. A systematic review and meta-analysis of dropout rates in youth soccer. *Percept Mot Skills*. (2015) 121(3):913–22. doi: 10.2466/10.PMS.121c23x0

51. Müller JC, Lammert J, Hovemann G. The financial fair play regulations of UEFA: an adequate concept to ensure the long-term viability and sustainability of European club football? *Int J Sport Finance*. (2012) 7(2):117–40. ISSN: 1558-6235, ZDB-ID 22171848

52. Romann M, Javet M, Cobley S, Born D-P. How relative age effects associate with football players' market values: indicators of losing talent and wasting money. *Sports (Basel)*. (2021) 9(7):99. doi: 10.3390/sports9070099

53. Wattie N, Cobley S, Baker J. Towards a unified understanding of relative age effects. *J Sports Sci*. (2008) 26(13):1403–9. doi: 10.1080/02640410802233034

54. Helsen WF, Starkes J. Relative age effects in youth and elite sport. In: Dixon JC, Horton S, Chittle L, Baker J, editors. *Relative age effects in sport: International perspectives*. New York: Routledge (2020). p. 98–116.

55. Dixon J. *Relative age effects in sport: international perspectives (routledge research in sport and exercise science)*. 1st ed. New York: Routledge (2020).

56. Olmedilla A, Torres-Luque G, García-Mas A, Rubio VJ, Ducoing E, Ortega E. Psychological profiling of triathlon and road cycling athletes. *Front Psychol*. (2018) 9:825. doi: 10.3389/fpsyg.2018.00825

57. Giacobbi PR, Whitney J, Roper E, Butryn T. College coaches' views about the development of successful athletes: a descriptive exploratory investigation. *J Sport Behav*. (2002) 25:164–80.

58. Morris T. Psychological characteristics and talent identification in soccer. *J Sports Sci*. (2000 Sep) 18(9):715–26. doi: 10.1080/02640410050120096

59. Van Yperen NW. Why some make it and others do not: identifying psychological factors that predict career success in professional adult soccer. *Sport Psychol*. (2009) 23(3):317–29. doi: 10.1123/tsp.23.3.317

60. Gledhill A, Harwood C, Forsdyke D. Psychosocial factors associated with talent development in football: a systematic review. *Psychol Sport Exerc*. (2017) 31:93–112. doi: 10.1016/j.psychsport.2017.04.002

61. Helsen WF, Starkes JL, Van Winckel J. Effect of a change in selection year on success in male soccer players. *Am J Hum Biol*. (2000) 12(6):729–35. doi: 10.1002/1520-6300(200011/12)12:6<729::AID-AJHB2>3.0.CO;2-7

62. Helsen WF, Hodges NJ, Van Winckel J, Starkes JL. The roles of talent, physical precocity and practice in the development of soccer expertise. *J Sports Sci*. (2000) 18 (9):727–36. doi: 10.1080/02640410050120104

63. Sherar LB, Baxter-Jones ADG, Faulkner RA, Russell KW. Do physical maturity and birth date predict talent in male youth ice hockey players? *J Sports Sci*. (2007) 25 (8):879–86. doi: 10.1080/02640410600908001

64. Sherar LB, Esliger DW, Baxter-Jones ADG, Tremblay MS. Age and gender differences in youth physical activity: does physical maturity matter? *Med Sci Sports Exerc*. (2007) 39(5):830–5. doi: 10.1249/mss.0b013e3180335c3c

65. Malina RM, Rogol AD, Cumming SP, Coelho e Silva MJ, Figueiredo AJ. Biological maturation of youth athletes: assessment and implications. *Br J Sports Med*. (2015) 49(13):852–9. doi: 10.1136/bjsports-2015-094623

66. Lefevre J, Beunen G, Steens G, Claessens A, Renson R. Motor performance during adolescence and age thirty as related to age at peak height velocity. *Ann Hum Biol*. (1990) 17(5):423–35. doi: 10.1080/03014469000001202

67. Kirk D. Physical education, youth sport and lifelong participation: the importance of' ' early learning experiences. *Eur Phy Educ Rev*. (2005) 11(3):239–55. doi: 10.1177/1356336X05056649

68. Gould D, Dieffenbach K, Moffett A. Psychological characteristics and their development in Olympic champions. *J Appl Sport Psychol*. (2002) 14(3):172–204. doi: 10.1080/10413200290103482

69. Orlick T, Partington J. Mental links to excellence. *Sport Psychol*. (1988) 2 (2):105–30. doi: 10.1123/tsp.2.2.105

70. McCarthy N, Collins D. Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road? *J Sports Sci*. (2014) 32 (17):1604–10. doi: 10.1080/02640414.2014.908322

71. Fumarco L, Gibbs BG, Jarvis JA, Rossi G. The relative age effect reversal among the National Hockey League elite. *PLoS One*. (2017) 12(8):e0182827. doi: 10.1371/journal.pone.0182827

72. Baker J, Young BW, Mann D. Advances in athlete development: understanding conditions of and constraints on optimal practice. *Curr Opin Psychol*. (2017) 16:24–7. doi: 10.1016/j.copsyc.2017.03.005

73. Mills A, Butt J, Maynard I, Harwood C. Identifying factors perceived to influence the development of elite youth football academy players. *J Sports Sci*. (2012) 30 (15):1593–604. doi: 10.1080/02640414.2012.710753

74. Hackfort D, Birkner H. Triangulation as a basis for diagnostic judgments. *Int J Sport Exerc Psychol*. (2003) 1(1):82–94. doi: 10.1080/1612197X.2003.9671705

75. Giacobbi P, Poczwardowski A, Hager P. A pragmatic research philosophy for applied sport psychology. *Sport Psychol*. (2005) 19:18–31. doi: 10.1123/tsp.19.1.18

76. Mann DL, van Ginneken PJMA. Age-ordered shirt numbering reduces the selection bias associated with the relative age effect. *J Sports Sci*. (2017) 35 (8):784–90. doi: 10.1080/02640414.2016.1189588

77. Malina RM, Cumming SP, Rogol AD, Coelho-E-Silva MJ, Figueiredo AJ, Konarski JM, et al. Bio-banding in youth sports: background, concept, and application. *Sports Med*. (2019) 49(11):1671–85. doi: 10.1007/s40279-019-01166-x

78. Romann M, Lüdin D, Born D-P. Bio-banding in junior soccer players: a pilot study. *BMC Res Notes*. (2020) 13(1):240. doi: 10.1186/s13104-020-05083-5

79. Salter J, De Ste Croix MBA, Hughes JD, Weston M, Towlson C. Monitoring practices of training load and biological maturity in UK soccer academies. *Int J Sports Physiol Perform*. (2021) 16(3):395–406. doi: 10.1123/ijspp.2019-0624

80. Bio-banding in academy football: Player's perceptions of a maturity matched tournament. Available at: http://www.open-access.bcu.ac.uk/id/eprint/8982 [cited 2022 Jun 28].

81. Cumming SP, Lloyd RS, Oliver JL, Eisenmann JC, Malina RM. Bio-banding in sport: applications to competition, talent identification, and strength and conditioning of youth athletes. *Strength Cond J*. (2017) 39(2):34–47. doi: 10.1519/SSC.0000000000000281

82. Reeves MJ, Enright KJ, Dowling J, Roberts SJ. Stakeholders' understanding and perceptions of bio-banding in junior-elite football training. *Soccer Soc*. (2018) 19(8):1166–82. doi: 10.1080/14660970.2018.1432384

83. Bradley B, Johnson D, Hill M, McGee D, Kana-Ah A, Sharpin C, et al. Bio-banding in academy football: player's perceptions of a maturity matched tournament. *Ann Hum Biol*. (2019) 46(5):400–8. doi: 10.1080/03014460.2019.1640284

84. Birrer D, Morgan G. Psychological skills training as a way to enhance an athlete's performance in high-intensity sports. *Scand J Med Sci Sports*. (2010) 20(Suppl 2):78–87. doi: 10.1111/j.1600-0838.2010.01188.x

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# Monitoring load, wellness, and psychological variables in female and male youth national team football players during international and domestic playing periods

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**Aim:** To study differences in total load exposure, wellness, and psychological variables in youth female ($N = 19$) and male ($N = 20$) national team football players during domestic and international playing periods, respectively.
**Procedures:** The players filled out questionnaires on well-being, stress, and resilience before and after both playing periods lasting 8 days each. The Hooper index was used to monitor daily wellness levels during both playing periods. The number of training sessions and matches were recorded, and the session rating of perceived exertion was collected. Training load, monotony, and strain were calculated. Daily measurements were used to evaluate in-period changes, and composite scores were used to describe differences between periods.
**Results:** The international compared to the domestic playing period was for both groups characterized by more matches played, longer field training session durations, and of fewer gym-based sessions ($P < 0.05$). The male players increased total exposure time (25%; $P < 0.05$), monotony ($P < 0.001$), and strain ($P < 0.001$), which was not changed in the female players. Well-being decreased ($P < 0.05$) during the international playing period in male players. Stress levels were higher ($P < 0.05$) for both genders during the international compared to the domestic playing period. During the international playing period, positive correlations were found between the initial levels of stress, and the change in stress ($P = 0.03$; $r^2 = 0.12$), and between the changes in total load and changes in well-being ($P = 0.02$; $r^2 = 0.12$), whereas a negative correlation was found between the changes in wellness and stress ($P = 0.03$; $r^2 = 0.14$).
**Conclusion:** A playing period characterized by increased match focus, longer field training sessions, and fewer gym-based training activities may lead to changes in the physical and mental profiles of youth national team football players. Alterations to load exposure and wellness may influence mental health. Players with high initial stress levels may be subjected to greater changes compared to other players. Sports scientists and medical staff may benefit from initiating structured monitoring systems to track alterations in physical load and mental health in youth national team players.

KEYWORDS

mental health, Hooper index, well-being, stress, training load, monotony, strain, elite

# Introduction

The demands of elite-level football have been shown to increase over time (1, 2), and is expected to continuously increase for both female and male players (3, 4). The potential combination of increased physical strain (e.g., more high-intensity training sessions and matches) and psychological stress (e.g., internal/external psychological pressure and intensified travel schedules) may lead to an increased risk of injury (5), as well as a decrease in mental health and well-being (6). In young talented players, new trends indicate that future injury patterns (7), match and training structures (8), as well as elite sports context (9), will be comparable to those of adult elite-level players. Hence, the needs for balancing match and training loads, to ensure optimal recovery, and promote mental health will require an intensified focus also for young players (10).

Physical load may simplistically be divided into external load (e.g., training/match frequency and duration, distance covered in different movement intensity categories etc.) and the associated internal response load (e.g., heart rate, perception of effort). Long- as well as short-term increases in internal load have been shown to be associated with over-training (11), increased risk of injury (12), and increased need for rest and recovery (13). Similarly, sudden changes in normal routines (e.g., extensive travelling, fixture congestion etc.) may negatively influence psychological state variables such as well-being or perceived stress levels (14). Psychological states can be described as characteristic patterns of thinking, feeling, and behaving in a concrete situation at a specific moment in time (15). These can relatively easily be monitored through questionnaires or interviews. The prevalence of mental health problems and mental illness is widespread and increasing among young people (16). In elite sports, athletes are pushing their physical and mental boundaries to enhance performance, and the consequences may be adverse (17). Recently, a study assessed the prevalence of depressive symptoms in Danish elite athletes participating in individual as well as team sports. The study found that female athletes were over-represented in the high-risk depression group (18). Interestingly, a recent study from the Danish premier league also showed, that high resilience (described as the ability to bounce back in times of adversity) may act as a protective factor for mental health. Hence, the level of resilience may potentially impact players' ability to perform and be ready for practice under difficult conditions such as during period with high physical and mental loading (19).

High physical and mental demands are frequently observed in football. Especially during congested match fixtures (20), which is common in professional adult football (21). This may also be the case for international level youth players, who frequently participate in national team training camps or competitions during the playing season (typically on UEFA international dates, 4–7 times/year). Previous research on match fixture congestion in football has mostly focused on adult female and male adult players separately, and with an exclusive focus on changes in either recovery, physical, technical, tactical, cognitive, or mental performance, respectively. Only a few studies [e.g., (20)], have attempted to include measures of changes in physical and mental performance simultaneously.

Therefore, the present study aimed to investigate physical exposure, wellness, and psychological variables in female and male youth national team football players during a domestic playing period with low match frequency in comparison to an international playing period with match fixture congestion.

# Materials and methods

## Participants

Forty-eight female and male international level youth football players selected for the Danish female (FU19) or male (MU19) under-19 national teams were invited to participate in the present study. Inclusion criteria were selected as: female or male youth elite football player selected for the national team roster from August 1st to Nov 30th' 2021. Exclusion criteria were selected as injury or illness resulting in training or match absence during the investigation period, and failure to report data according to the investigation protocol. Of the eligible players, one player declined to participate, and seven players (FU19 = 3; MU19 = 4) accepted to participate but dropped out prior the investigation or during the domestically based monitoring period due to injuries. One player was excluded due to failure to report data. In total, 39 (FU19 = 19; MU19 = 20) players were included in the final analyses. The age of the included players ranged from 16 to 18 years with an average age of 17.9 ± 0.6 years (mean ± SD) and 18.3 ± 0.4 years for the female and male players, respectively. Individual playing positions were distributed as goalkeepers ($N = 4$, 10%), defenders ($N = 8$, 20%), midfielders ($N = 16$, 40%), and strikers ($N = 12$, 25%).

## Procedures

The present investigation was conducted as an integrated part of the overall team preparation leading up to the UEFA 2021 European qualifying rounds for FU19 or MU19. The players were separately monitored during a national team training camp on UEFA international playing dates (international playing period; IPP) lasting eight days as well as during a domestic playing period (DPP) of similar duration. Player resilience, perceived stress, and well-being were monitored simultaneously pre- and post-to the IPP and DPP, respectively. During IPP the FU19 played three matches (2 wins—1 draw), and MU19 played two matches (2 wins). On each day during IPP and DPP, the players filled out a five-point Hooper questionnaire in the morning before breakfast to monitor recovery and wellness. The number of training sessions and matches during IPP and DPP, respectively, was recorded separately for all players. In addition, the perceived intensity was individually assessed after each training or match activity. The duration of the activity was registered. The players were familiarized with all data collection procedures prior to the beginning of the investigation. During

IPP an DPP, dedicated national team staff members were responsible for all player monitoring procedures, with the data during IPP being collected on-site, and with the data during DPP being transferred to the data collector electronically via applications (22, 23).

## Measurements

### The Connor-Davidson resilience scale (CD-RISC-10)

The Connor-Davidson Resilience Scale [CD-RISC-10; Connor and Davidson (24)] was used to measure the ability to cope with adversity. On a Likert-scale ranging from 0 (not true at all) to 4 (true nearly all the time), the players were asked to think about the last month and answer 10 questions (e.g., "I am able to adapt when changes occur" and "I am not easily discouraged by failure"). A total sum score was calculated (range: 0–40) with higher scores indicating greater resilience ($\alpha = 0.73$). A composite score of pre- and post-measurements was calculated to represent the average resilience of MU19 and FU19 during IPP and DPP, respectively. The CD-RISC-10 has previously been shown to produce adequate levels of internal consistency within a sport context (25).

### Perceived stress scale (PSS-10)

The COHEN Perceived Stress Scale [PSS-10; Cohen, Kamarck (26)] was used to measure levels of perceived stress. On a Likert-scale ranging from 0 (never) to 4 (very often), the players were asked to think about the last month and answer 10 questions (e.g., "in the last month, how often have you felt nervous and "stressed"?" and "In the last month, how often have you felt that things were going your way?"). A PSS-10 score was calculated by summation across all 10 items after inverting the scores on the four positive items (items 6, 7, 8, and 9) ($\alpha = 0.82$). A score between 0 and 13 corresponded to a person who "knows how to manage stress". A score between 14 and 26 corresponded to a person who "generally knows how to cope with stress". A score between 27 and 40 corresponded to a person where life is considered a "perpetual threat". A composite score of pre- and post-measurements was calculated to represent the average stress level of MU19 and FU19 during IPP and DPP, respectively. The PSS-10 has previously been shown to produce adequate levels of internal consistency within a sport contexts ($\alpha$'s = 0.82) (27).

### The world health organization-5 index (WHO-5)

The World Health Organization-5 index [WHO-5; Organization (28)] was used to measure player well-being status. On a Likert-scale ranging from 0 (at no time) to 5 (all the time), the players were asked to answer five questions based on the preceding two weeks (e.g., "I have felt cheerful and in good spirits" and "I have felt active and vigorous"). A WHO-5 score was calculated by the sum of the five answers multiplied by 4 (Range: 0–100) with higher scores indicating good well-being ($\alpha = 0.76$). A composite score of pre- and post-measurements was calculated to represent the average well-being of MU19 and FU19 during IPP and DPP, respectively. The WHO-5 has previously been shown to shown to produce adequate levels of internal consistency within a sport context ($\alpha$'s $\geq 0.70$) (29).

### Recovery and wellness conditions (the Hooper index)

The Hooper index (30) was used to measure player recovery and wellness conditions covering 5 areas (fatigue, sleep quality and time, muscle soreness and psychological wellbeing, respectively). On a Likert-scale ranging from 1 (very, very low or good) to 7 (very, very high or bad) the players rated one question for each subscale: fatigue (e.g., "How fatigued are you?"), sleep quality (e.g., "How was your sleep last night?"), sleep duration (e.g., "How many hours did you sleep last night?"), muscle soreness (e.g., "Please rate your level of muscle soreness") and psychological [e.g., "How are you feeling psychologically (mentally)?]. The score (min 1–max 7) of each item was evaluated, and a total Hooper score was calculated as the total sum of all item scores (Range: 1–35) ($\alpha = 0.90$). Period mean and a coefficient of variation (C.V. = standard deviation across all individual daily scores divided by the mean multiplied by 100) were calculated for each variable to evaluate variations on total Hooper score and wellness sub-scale scores during IPP and DPP, respectively. The Hooper Index has previously shown adequate levels of internal consistency within a sport context (31).

### Training sessions and matches

During IPP, the training and match plans for FU19 and MU19, respectively, were organized by the national team staff. During DPP, FU19 and MU19 adhered to the training and match plans organized by their individual clubs. Training sessions were registered as either field or gym sessions, and match participation was reported when a player had been actively involved in international, official league or reserve team matches. Time exposure (training session duration or match playing time) was reported in minutes.

### Session rating of perceived exertion and training load

Not later than 30 min after cessation of a training session or a match, the players rated their perceived exertion (sRPE) on a 1 (light/easy) to 10 (maximal/hard) point Likert-scale (32). Training load (TL) or match load (ML) was subsequently calculated as TL/ML (A.U.) = sRPE multiplied by activity duration (min). Monotony and strain were calculated as: Monotony = average daily TL divided by the standard deviation of the daily TL monitored during IPP or DPP, respectively, and Strain = Sum of daily TL monitored during IPP or DPP, respectively, multiplied by Monotony. The validity and reliability of the above concepts has previously been reviewed (33).

### Ethical considerations

Prior to the beginning of the investigation, the players received written and oral information about all study aims as well as associated risks, benefits, and procedures before giving their written and informed consent to participate. If a player at the

beginning of the study period was a minor, informed consent was signed by a parent/legal guardian. Participation in the study was voluntary, and a players could withdraw from participation at any time without further notice. The study was reviewed and approved by a local ethics committee (Ethic Committee of Southern Denmark).

## Calculations and statistical analyses

All variables were tested for normal distribution according to Shapiro-Wilk to justify for the use of parametric statistics. In case of non-normalized distributed data, non-parametric alternatives were applied. Cronbach's alpha was used to test internal consistency reliability of the subscales of CD-RISC-10, PSS-10, WHO-5, and The Hooper Index. A threshold ($\alpha \geq 0.70$) was applied for acceptable reliability. To evaluate within-group changes (FU19 or MU19) between IPP and DPP, respectively, a one-way repeated measures ANOVA was performed separately with stress, resilience, and well-being as the independent variables, and pre- and post-measures for IPP and DPP as the dependent variables. A series of one-way between-subjects ANOVA with repeated measures on wellness (fatigue, sleep quality, sleep duration, muscle soreness, and mental) as the independent variable and with FU19 and MU19 as the grouping variable, was performed for IPP and DPP, respectively. A $2 \times 2$ contingency table with the application of a Fischer's exact test were applied to evaluate the hypothesis of independence (0-hypothesis) of group (FU19 vs. MU19) and change (increase vs. no change/decrease) during IPP compared to DPP. Correlations were evaluated according to Spearman. For all analyses, $P < 0.05$ was chosen as the level of significance. Data are presented as mean ± SEM unless otherwise stated. All statistical analyses were performed using SPSS Statistics 25 (SPSS, IBM, US).

# Results

In FU19 and MU19, total load exposure was not different ($P > 0.05$) during IPP compared to DPP. FU19 had on average a 10% lower ($P < 0.05$) total number of training sessions and matches during IPP compared to DPP. MU19 on average had a 10% higher ($P < 0.05$) total number of training sessions and matches and a 25% higher (113 ± 26 min; $P < 0.001$) total exposure time during IPP compared to DPP (Table 1). Similar proportions of FU19 and MU19 experienced an increase in total exposure time during IPP compared to DPP ($Chi^2$ Fisher Exact; $P = 0.32$).

During IPP, the number of match participations increased ($P < 0.001$) compared to DPP in FU19 as well as in MU19. No differences in average total match exposure time and average match load were observed. During IPP, FU19 had a smaller ($P < 0.001$) total number of training sessions and gym-based sessions, respectively, and the average training session duration was longer (Average: + 14 min; $P < 0.001$) compared to DPP. In MU19, the total number of training session was unchanged, whereas the number of field session was greater ($P < 0.01$) and the number of gym-based session was smaller ($P < 0.001$) during IPP compared to DPP. During IPP, the duration of training sessions was longer (Average: + 15 min; $P < 0.001$) in MU19, and the average training session load was higher ($p < 0.05$) compared to DPP (Table 1). Monotony and strain increased ($P < 0.001$) during IPP compared to DPP in MU19 and was unchanged in FU19 (Table 1).

In FU19, marked between-player variations were observed both during IPP and DPP, respectively, for load (range IPP: 2274A.U.-3829A.U.; range DPP: 1740A.U.-4554A.U.), monotony (range IPP: 1.20A.U.-2.39A.U.; range DPP: 1.10A.U-2.10A.U.), and strain (range IPP: 3255U.A-8440A.U; range DPP: 2934A.U.-9375A.U) (Figure 1). In FU19, 37%, 63%, and 53% of the

TABLE 1 Total match and training session exposure in FU19 and MU19 during an IPP and a DPP of equal (8 days) duration.

| | Female U19 | | Male U19 | |
|---|---|---|---|---|
| | DPP | IPP | DPP | IPP |
| **Total exposure** | | | | |
| Total number of training sessions and matches (no.) | 8.3 ± 0.4 | 7.5 ± 0.1* | 6.8 ± 0.3 | 7.5 ± 0.2* |
| Total exposure time (min) | 544 ± 20 | 556 ± 12 | 441 ± 25 | 553 ± 21*** |
| Total load (A.U.) | 3,403 ± 158 | 3,125 ± 98 | 2,489 ± 171 | 2,777 ± 120 |
| Monotony (A.U.) | 1.52 ± 0.06 | 1.65 ± 0.06 | 1.31 ± 0.08 | 2.07 ± 0.12*** |
| Strain (A.U.) | 5,245 ± 406 | 5,208 ± 290 | 3,320 ± 361 | 5,927 ± 540*** |
| **Matches** | | | | |
| Average match participation (no.) | 1.1 ± 0.1 | 2.8 ± 0.1*** | 1.4 ± 0.2 | 1.9 ± 0.1*** |
| Average match time exposure (min) | 51 ± 11 | 53 ± 7 | 61 ± 12 | 52 ± 8 |
| Average match load (A.U.) | 515 ± 118 | 546 ± 80 | 482 ± 97 | 385 ± 57 |
| **Training sessions** | | | | |
| Average number of training sessions (no.) | 7.3 ± 0.4 | 5.0 ± 0.0*** | 5.5 ± 0.3 | 5.6 ± 0.2 |
| Average number of field sessions (no.) | 4.9 ± 0.3 | 4.8 ± 0.1 | 4.8 ± 0.3 | 5.6 ± 0.2** |
| Average number of gym sessions (no.) | 2.4 ± 0.4 | 0.2 ± 0.1*** | 0.7 ± 0.2 | 0.0 ± 0.0*** |
| Average session duration (min) | 65 ± 9 | 79 ± 4*** | 64 ± 9 | 80 ± 7*** |
| Average training session load (A.U.) | 366 ± 67 | 355 ± 68 | 312 ± 76 | 362 ± 57* |

*$P < 0.05$;.
**$P < 0.01$;.
***$P < 0.01$ significantly different DPP vs. IPP within FU19 and MU19, respectively. Numbers are presented as mean ± SEM.

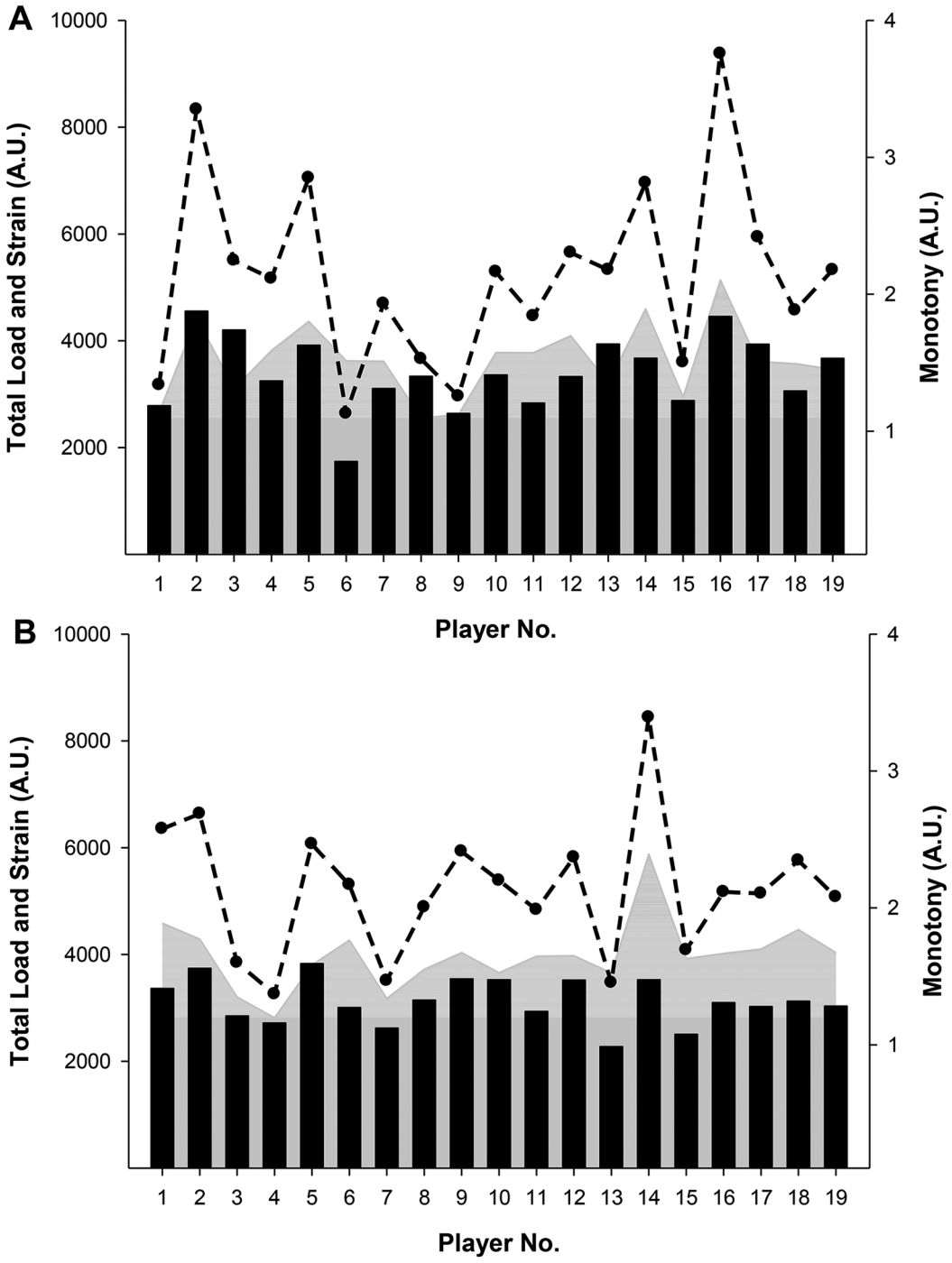


FIGURE 1
Total load (bars), monotony (grey), and strain (line) in female under-19 national team players during a domestic (A) and an international (B) playing period. Individual values are presented.

players experienced an increase in load, monotony, and strain, respectively, during IPP compared to DPP. The relative difference between IPP compared to DPP for load, monotony, and strain ranged from −42% to 72%, −25% to 65%, and −44 to 101%, respectively (Figures 1A,B). Similarly in MU19 significant between-player variation was observed during IPP and DPP for load (range IPP: 1995A.U.-3948A.U.; range DPP: 1086A.U.-3880A.U.), monotony (range IPP: 1.37A.U.-3.20A.U.; range DPP: 0.84A.U-2.06A.U.), and strain (range IPP: 2970U.A-10879A.U; range DPP: 1427A.U.-7348A.U) (Figure 2). In MU19, 70%, 85%, and 90% of the players experienced an increase in load, monotony, and strain, respectively, compared to DPP with the relative difference between IPP compared to DPP for load, monotony, and strain ranging from −29% to 136%, −28% to 224%, and −44 to 662%, respectively (Figures 2A,B). More ($p <$ 0.05) players in MU19 compared to FU19 experienced an

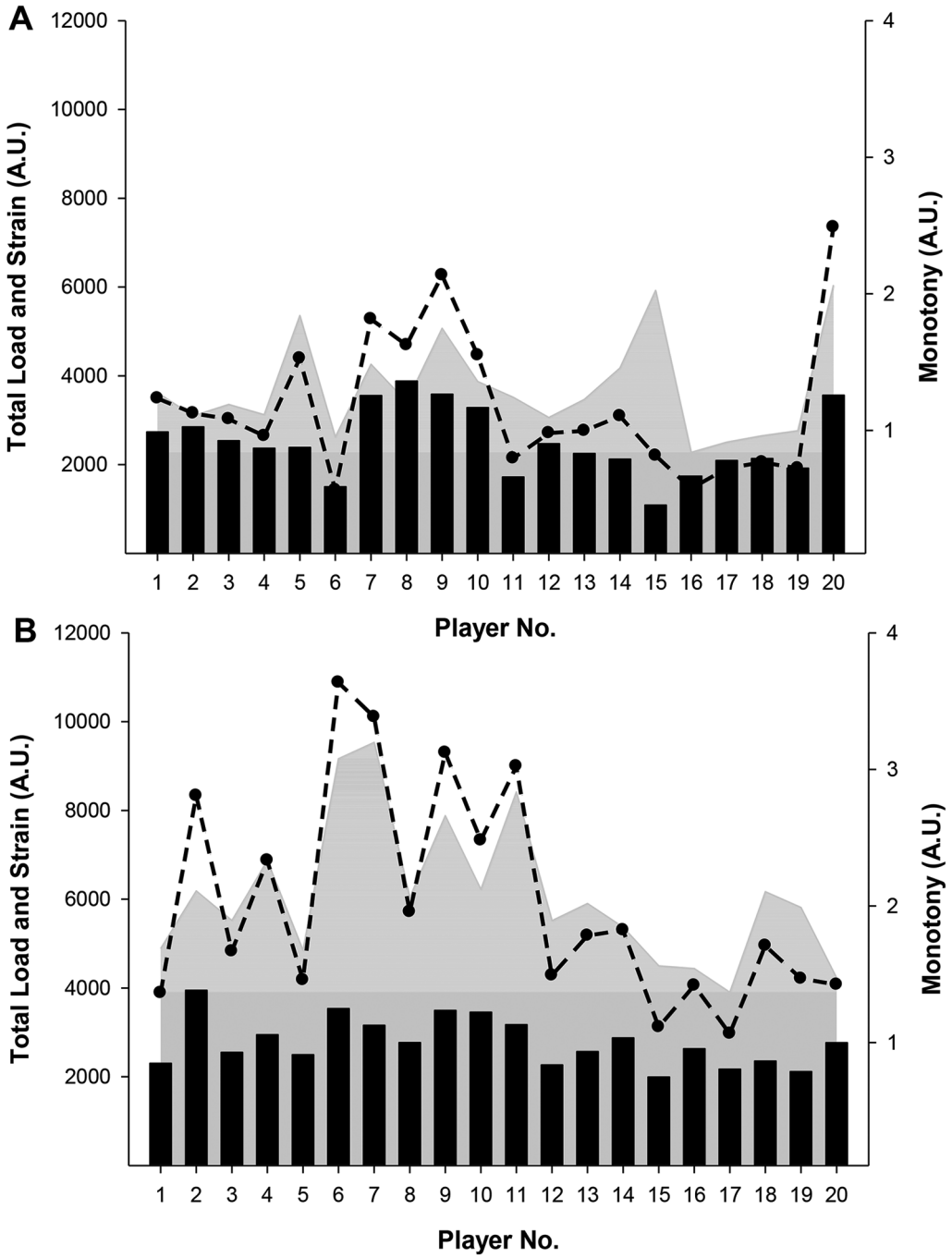


FIGURE 2
Total load (bars), monotony (grey), and strain (line) in male under-19 national team players during a domestic (A) and an international (B) playing period. Individual values are presented.

increase in strain during IPP compared to DPP, with no differences observed for load and monotony.

A credible variance indicating heterogeneity was observed between measurements obtained pre- and post- IPP and DPP, respectively, for well-being, stress, and resilience in both FU19 and MU19. Significant group differences were found between FU19 and MU19 in well-being (WHO-5) levels for post-test [$F(1.36) = 7.44$, $P < 0.001$] during IPP, with no pre- to post-level differences observed for stress and resilience. Composite stress score (PSS-10) analysis revealed a significant difference between IPP and DPP in both FU19 ($15.1 \pm 1.0$ vs. $13.0 \pm 1.4$; $P < 0.05$) and MU19 ($15.5 \pm 1.2$ vs. $12.1 \pm 06$; $P < 0.001$), with no differences observed for WHO-5 and CD-RISC-10 (**Figure 3**). Similar proportions of players in FU19 and MU19, respectively, experienced increases in stress, resilience, and well-being, respectively, during IPP compared to DPP (**Figure 3**; $P > 0.05$).

Average total Hooper index scores was not different and total Hooper scores C.V. was larger ($P < 0.05$) during IPP compared to

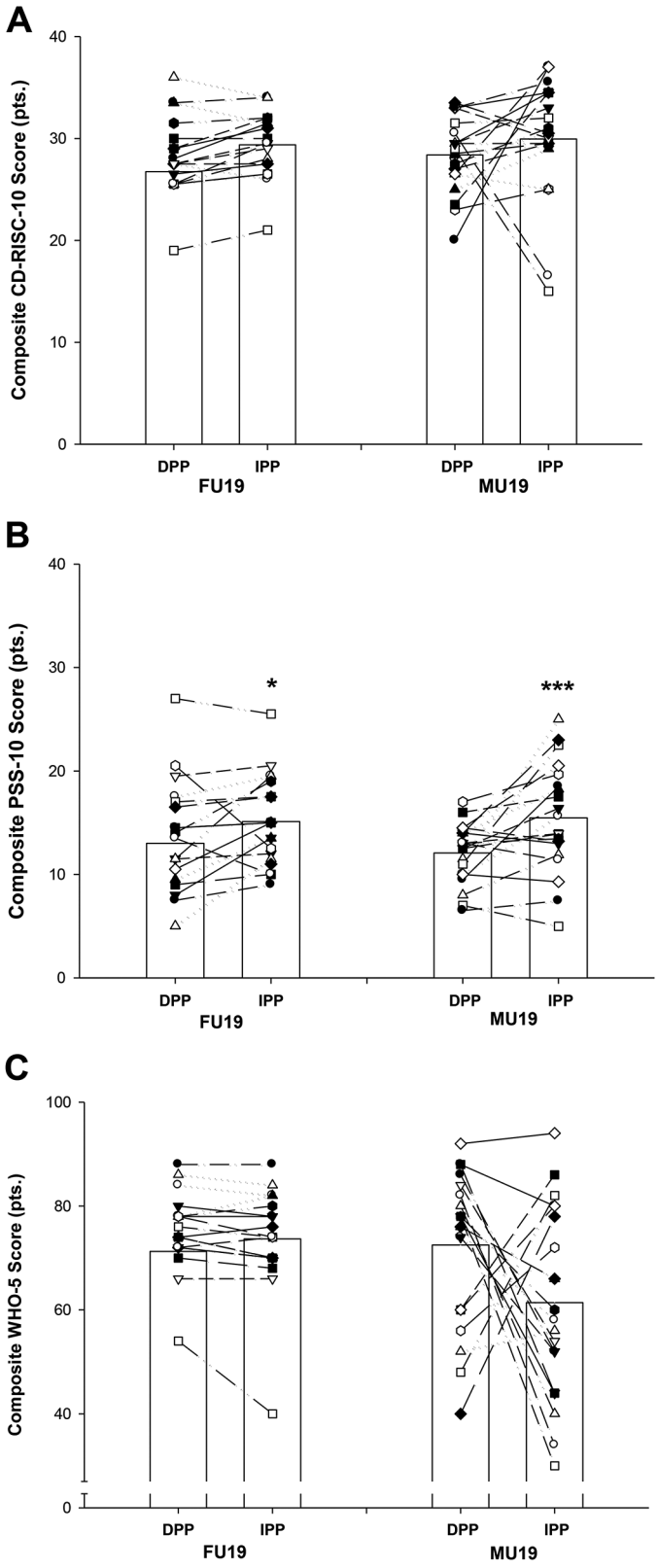


FIGURE 3
Composite CD-RISC-10 (**A**), PSS-10 (**B**), and WHO-5 (**C**) scores for a domestic (DPP) and an international (IPP) playing period in female (FU19) and male (MU19) national team football players. Bars are mean ± SEM. $^{*}P < 0.05$. $^{***}P < 0.001$. Individual values are presented.

TABLE 2 Total Hooper index and sub-scales scores in FU19 and MU19 during an IPP and a DPP of equal (8 days) duration.

| | Female U19 | | | | Male U19 | | | |
|---|---|---|---|---|---|---|---|---|
| | DPP | | IPP | | DPP | | IPP | |
| | Mean | C.V. | Mean | C.V | Mean | C.V. | Mean | C.V |
| Total Hooper score | 16.4 ± 0.5 | 16.9 ± 1.5 | 15.7 ± 0.5 | 20.9 ± 1.2* | 16.2 ± 0.7 | 16.8 ± 1.4 | 14.4 ± 0.8 | 37.2 ± 3.3*** |
| Q1—fatigue | 3.4 ± 0.2 | 19.7 ± 2.0 | 3.6 ± 0.1 | 26.3 ± 2.6* | 3.4 ± 0.2 | 28.3 ± 3.9 | 3.4 ± 0.2 | 19.8 ± 2.5 |
| Q2—sleep quality | 2.9 ± 0.2 | 27.8 ± 3.3 | 3.2 ± 0.2 | 32.5 ± 2.1 | 3.1 ± 0.2 | 23.6 ± 2.7 | 3.4 ± 0.2* | 24.9 ± 3.3 |
| Q3—sleep duration | 3.6 ± 0.2 | 29.9 ± 2.8 | 3.0 ± 0.1** | 50.0 ± 1.8*** | 3.6 ± 0.1 | 24.2 ± 2.2 | 3.5 ± 0.2 | 17.0 ± 2.0* |
| Q4—muscle soreness | 3.5 ± 0.2 | 21.4 ± 2.8 | 3.5 ± 0.1 | 23.1 ± 2.9 | 3.4 ± 0.2 | 24.0 ± 2.5 | 3.2 ± 0.2 | 20.6 ± 3.6 |
| Q5—mental wellness | 3.3 ± 0.2 | 19.9 ± 2.8 | 2.9 ± 0.2 | 22.8 ± 3.7 | 3.0 ± 0.2 | 13.7 ± 3.1 | 2.8 ± 0.2 | 15.2 ± 3.3 |

*$P < 0.05$;.
**$P < 0.01$;.
***$P < 0.001$ significant difference DPP vs. IPP within FU19 and MU19, respectively. Numbers are presented as mean ± SEM and coefficient of variation (C.V.) ±SEM.

DPP for both FU19 and MU19, respectively (Table 2). During IPP, within-subjects differences were found in one of five sub-scale wellness scores [sleep quantity: $F(1.1) = 20.615$, $P < 0.001$]) indicating significant improvement for the FU19 at the beginning of the IPP. During DPP, no sub-scale wellness score within-subject differences were observed ($P > 0.05$).

In FU19, sub-scale analyses revealed a on average significantly longer ($P < 0.001$) sleep duration during IPP compared to DPP, whereas MU19 reported a decreased ($P < 0.05$) sleep quality during IPP compared to DPP. FU19 and MU19 had a larger ($P < 0.001$) respectively smaller ($P < 0.05$) variation in sleep quality during IPP compared to DPP. In FU19, a larger ($P < 0.05$) variation in fatigue was reported during IPP compared to DPP (Table 2).

For all subjects, a significant positive correlation was found between the relative change (IPP vs. DPP) in total Hooper score and the relative change in composite stress (PSS-10; $P = 0.02$; $r^2 = 0.12$) as well as between the pre-levels of stress at the beginning of IPP and the change in stress during IPP ($P = 0.03$; $r^2 = 0.12$). Furthermore, a negative correlation was found between the relative change in total load and the relative change in composite well-being (WHO-5; $P = 0.03$; $r^2 = 0.14$), respectively (Figure 4).

## Discussion

The present study investigated changes in physical exposure, wellness, and psychological variables in female and male youth national team football players during international and domestic playing periods. The main findings were, that female and male under-19 national team football players took part in more matches, had longer lasting field training sessions, and had less gym-based training activities during an international period. Also, during an international playing period, the male players had an increase in total exposure time, monotony, and strain. This was not different in the female players. In the male players, well-being was observed to decrease during the international playing period, whereas stress levels were higher for both genders during the international compared to the domestic playing period. Furthermore, moderately strong relationships were observed between the changes in total load and well-being as well as between the changes in wellness and stress, respectively. In addition, a weak-to-moderately strong correlation was found for all players between the initial levels of stress and the change (pre- to post) in stress during an international playing period. Collectively, alterations in load exposure and wellness may influence the mental health of high-level football players. In addition, players with high initial stress levels may be subjected to more unfavourable changes during congested playing periods.

During the international playing period, individual match involvement significantly increased (see Table 1). Congested match-playing periods in professional football, may compromise player recovery profiles compared to non-congested playing periods (defined as 1 or fewer matches within a 7-day period) (34, 35). Specifically for players with longer lasting match involvement (>60 min), substantial fluctuations in load and recovery variables have been observed (36). In our study, the average match playing time and load was moderate for either gender during both observational periods (see Table 1). The most frequent match duration in both genders was full playing time (equivalent to 90–95 min). However, subsequent analysis showed large variations in individual match playing time and load during the two periods (range female: 2–95 min and 10–950 A.U., respectively; range male players: 11–95 min and 100–950 A.U., respectively). Football is an intense intermittent sport, that exerts the entire performance spectrum with high concurrent cardiovascular, metabolic, and musculoskeletal fitness demands (37). Also, football has been shown to lead to physical fatigue (38), and to post-match changes in markers of inflammation, oxidative stress, and performance (39). Also, marked changes in anabolic-to-catabolic ratio (40), increased muscle damage (41), reduced wellness (42), and an increased risk of injury (12) have been reported following match play. Therefore, during both international and domestic playing periods, an augmented focus on specific recovery strategies taking into consideration between players variation (43) may be needed.

National team camps and international playing periods represents a unique context in elite football (44). Typically, limited time exist between the start of a camp and the first match. Similarly, only a few days separate subsequent matches. It has previously been shown that wellness and heart rate variability

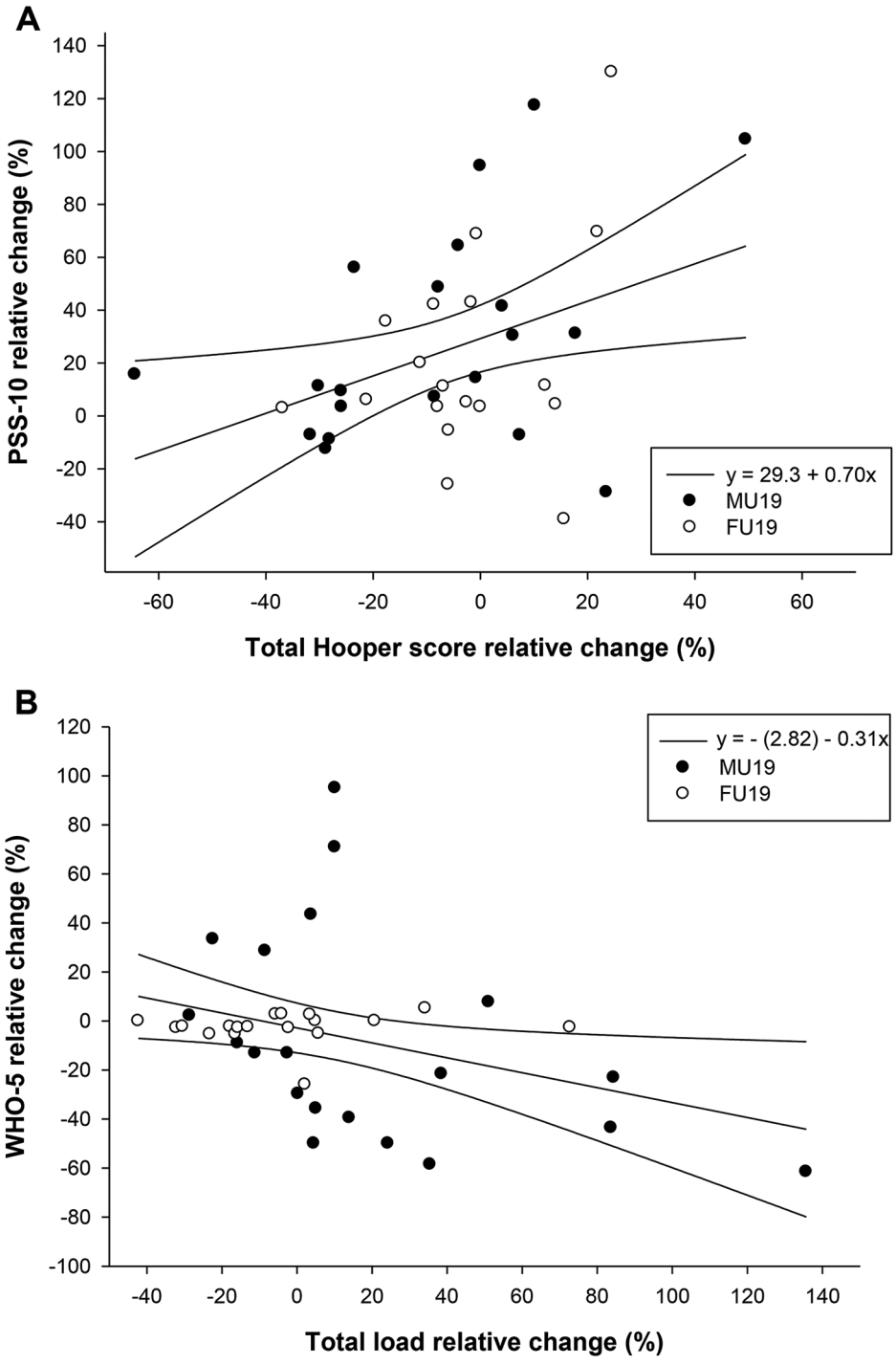


FIGURE 4
Correlations between relative changes in total Hooper (wellness) score and PSS-10 (stress) (panel A; $P = 0.02$; $r = 0.37$), and relative changes in total load (exposure) and wHO-5 (well-being) [panel B; $P = 0.03$; $r = -(0.35)$]. Individual values, line of regressions, and 95% confidence intervals are presented.

(31), perceived recovery status (45), and muscle glycogen levels (46) are compromised for several days following a match. Thus, during international playing periods, the ability to carefully accommodate both effective tactical training and sufficient player recovery may influence subsequent game performances. In this study, the average field training session duration was longer during the international compared to the domestic playing period. In addition to a higher game load, this could potentially have resulted in accumulation of fatigue in some players. However, the levels of general fatigue and muscle soreness were unchanged during the international playing period compared to the domestic playing period for both genders (see **Table 2**). As such, it appears that effective measures were taken by the coaching staff to reduce the risk of inappropriate accumulation of

fatigue. This was done by modifying the number of training sessions either on the field or in the gym, reducing general training intensity, and favouring recovery in players with prolonged match involvement (+45 min).

During the international playing period, female players experienced a reduction in the total number of training sessions and matches as well as in total load (−4% ± 26%). In contrast, the male players had an increase in the total number of training sessions and matches. Also, male players experienced average relative increases in total exposure time (33% ± 8%), total load (20% ± 41%), monotony (70% ± 58%), and strain (115% ± 151%), respectively. Studies have shown that the risk of injury may increase between 21% and 49% when training load is increased by ≥15% above the previous week's load (5). Also, monotony, a measure of day-to-day training variability, has been found to be related to the onset of overtraining and poor performance (11, 47). In this study, a considerable proportion of the players on both teams experienced a marked relative increase in load measures in the transition to the international playing period. Specifically, 28% ($N = 11$) of all players experienced a change in total load of 15% or more during the international compared to the domestic playing period. Also, three players had higher strain (Z-score > 2) during the international playing period than the team average. Therefore, several players may have been subjected to an increased risk of injury during the international playing period. However, no time-loss dependent injuries were recorded during the international playing periods or the week immediately following the national team camp in both teams. This indicates that the relative changes and variations in wellness and fatigue, respectively, were within the individual player tolerances. Interestingly, total Hooper index as a marker for wellness and recovery was not affected by match congestion, which is in accordance with previous findings (48).

Both teams had a significant increase in stress levels during the international compared to the domestic period. These findings are consistent with a recent study in elite players investigating mental health and emotional stability throughout a congested season finisher (19). The players in our study also experienced individual fluctuations in well-being levels during the study periods. This indicate that there are inter-individual differences in the way stressful periods are appraised by elite-level football players. The study by Madsen (19) found that resilience was a protective factor for players' well-being. Thus suggesting, that players with higher resilience levels also experienced higher levels and fluctuations of well-being. This emphasizes the importance of high resilience levels in avoiding negative psychological impacts during stressful training and match periods, as well as during times of adversity (14). In this study, all players were found to have reasonably high levels of resilience throughout the study period, which may have protected some but not all players from unfavourable changes in stress and well-being. Female players' well-being was observed to be stable. In contrast, negative changes in well-being between the international and domestic playing periods were observed in several male players, and with some approaching critical levels (see **Figure 3**). Resilience was found to be unrelated to changes in stress and well-being, indicating that other factors may have caused the observed changes.

As a novel finding, this study established an associations between the relative change in total wellness and the relative change in composite stress ($r^2 = 0.12$). Also, a correlation between the relative change in total load and the relative change in composite well-being was found ($r^2 = 0.14$) (see **Figure 4**). As such, the ability of the coaching staff and medical team to effectively balance individual physical load and effective recovery activities, could potentially positively impact stress levels and well-being (49). Additionally, a significant positive correlation was found between the pre-levels of stress at the beginning of the international playing period and the change in stress during the international playing period ($r^2 = 0.12$). This indicate the need for effective monitoring systems to detect players at risk of increased stress. According to the calculated coefficients of determination, changes in total load and wellness accounted for a lesser proportion of the total variance of stress and well-being. However, in high-level football, minor changes in several variables may impact total over-all performance significantly.

During the international playing period, female players experienced an overall increase in sleep duration, while male players experienced a decrease in sleep quality compared to the domestic playing period. Also, at the beginning of the international playing period, female players significantly increased sleep duration (IPP Day-2 vs. IPP Day-1). Several factors may negatively impact sleep. The female players experienced a compressed travelling schedule on IPP Day-1. This may have affected sleep duration in the beginning of the playing period. Also, the female players were not employed on full-time professional contracts. The increase in overall sleep duration for female players may hence be related to increased opportunities to focus on football during the international playing period. The observed decrease in sleep quality in male players and the large variations in sleep quality in both teams during the international playing period may be due to several factors. Specifically, the players were hosted in double rooms, which has been shown to impact sleep in youth elite football players (50). Moreover, match frequency was increased in both teams, potentially resulting in changes in sleep patterns and subsequent in poorer sleep quality during the international playing period (51). Lastly, male players experienced a significant increase in strain during the international playing period. This may have significantly influenced sleep quality (49). Therefore, measures to address the incidence of reduced sleep quality and duration during congested match schedules may advantageously be established. This include optimized travel plans and match schedules, individually tailored training programs, mandatory rest periods, improved sleep hygiene, and an optimized diet (52).

Several limitations apply to the present investigation. Match results in IPP and DPP could have affected resilience, stress, and well-being differently in FU19 and MU19. This is a limitation of this study. Also, during the domestic playing period, training and match schedules were planned by the individual clubs. In contrast, activity schedules during the international playing period were managed by the national team coaching staff. Therefore, training and match exposures were not standardized

or controlled making it difficult to address between-team (gender) differences. In addition, the majority of the male players were full-time professionals. Such players have access to multiple club specialist, including sports psychologists and fitness coaches. Generally, the female players had a limited domestic set-up. Female players may consequently have experienced larger unintended variations in study variables during the domestic playing period due to lack of guidance. Furthermore, monitoring data was either collected immediately on-site during the international playing period or electronically reported during the domestic playing period. Subjective measures of exertion may be sensitive to time-delays from the end of physical activity to the time of actual reporting (33). Differences in time-delays between the two observational periods can thus not be excluded, which may have influenced our findings. Also, during the international playing period, all players were equipped with similar GPS-sensors during training sessions and matches. Due to hardware differences between the clubs, this was not possible during the domestic playing period. Large variations between different GPS-systems may exist (53). For this reason, evaluation of changes in external load and its relation to other study variables was not included in the study protocol. This limits the practical application of the findings, and may be a subject to future investigations. Moreover, the data collection in the present study was conducted during two playing periods of shorter (8 days) duration in each team. As such, the data material of the present study was reduced. Inclusion of more observational periods, which has recently been performed by others (48), would increase the robustness of our findings, and reduce the risk of performing type 2 statistical errors. Finally, using self-attributed questionnaires might be subjected to social-desirability bias. As such, players could have answered in a way that portrayed them in a positive light (i.e., answering high on resilience, well-being, and wellness, and low on stress) (54). Despite all staff members being clear upon ethical standards and not sharing results with coaches (potentially providing players with starting positions on the team) this aspect must be considered when interpreting our results.

In brief, this study examined physical exposure, wellness, and psychological variables in youth national team football players. Significant differences between a domestic playing period with low match frequency and an international playing period with match fixture congestion were observed. Specifically, differences in training and match structure between the two periods affected several load, wellness, and psychological variables in a gender-specific manner. Also, the study identified substantial variability in load exposure, recovery, and stress both within and between players during the study period. Finally, the results showed significant associations between changes in measures of recovery and stress, as well as between load and well-being, illustrating the complexity of holistic monitoring in elite team sport athletes.

## Practical implications

Staff members in elite football academies and national teams play vital roles in assisting youth players during challenging times. Therefore, the ability to provide practical recommendations aimed at supporting performance and mental health in youth international level football players may not be underestimated.

Based on our findings, we recommended to incorporate monitoring strategies in clubs and national teams based on quantitative evaluation of mental health-related aspects. Players' psychological states may fluctuate, and therefore, the staff supporting the players could benefit from additional insight into individually assessed mental performance and recovery cycles to initiate customized interventions. This can be accomplished by implementing a stringent procedure for systematically monitoring players' daily wellness using the Hooper Index and/or sleep-tracking devices as recommended by others (55). We suggest using the Hooper Index as part of the daily medical checks. This would allow players a short time to reflect on their wellness levels, providing sports specialists with important information about players' experience of load, recovery, and mental status. A medical check may also serve as an informal platform to individually check-in with the players on several specific personal and performance related domains. Subsequently, the information may be applied to adjust training, individually tailor daily routines, and secure optimal performance. Also, we recommend a continuous tracking of physical strain and exposure. Specifically, football association and clubs may strengthen their shared efforts to exchange individual player information on physical loading across professional barriers prior to and after national team camps and competitive events. This could potentially secure the national team players' continuous ability to perform at their highest possible level and reduce their risk of injury. This might also imply for the mental health condition of the players, as these aspects are important to consider. Based on our results, we also recommend systematic collaborations between sports psychologist working at federation and the club level, respectively, in terms of supporting players in the best possible way in the transition from domestic to international level football.

Based on empirical evidence and our applied experience, gender differences among elite-level team players must be considered. Specifically, female players express greater risk factors of depressive symptoms (18). As such, when players report poor well-being or high stress levels, we recommend addressing these areas via confidential conversations with a team sports psychologist and possibly a team physician. However, recent evidence suggests, that upholding client-psychologist confidentiality may be compromised in elite football (56). This line of research is imperative as limiting help-seeking, stigma toward psychology. Upholding confidentiality between the player, physician, and sports psychologist is pivotal to consider. Especially when setting up effective mental health support systems and assessing if further initiatives or measures are needed. Finally, continuous reviews of individual monitoring protocols are needed to ensure that measures are conducted with a purpose and are not characterized by widespread surveillance of players (57).

## 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 humans were approved by Ethics Committee of Southern Denmark. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

## Author contributions

Conceived and designed the study: TA, EM. Collected the data: TA, EM, MA, BK. Analyzed the data and interpreted the findings: TA, EM, MA, BK, CL. Wrote the paper: TA, EM, MA, BK, CL. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

TA, EM, and CL were employed at the Danish Football Association during the data collection period.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

1. Bush M, Barnes D, Archer B, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English premier league. *Hum Mov Sci*. (2015) 39:1–11. doi: 10.1016/j.humov.2014.10.003

2. Wallace JL, Norton KI. Evolution of world cup soccer final games 1966–2010: game structure, speed and play patterns. *J Sci Med Sport*. (2014) 17(2):223–8. doi: 10.1016/j.jsams.2013.03.016

3. Nassis GP, Massey P, Jacobsen P, Brito J, Randers MB, Castagna C, et al. Elite football of 2030 will not be the same as that of 2020: preparing players, coaches, and support staff for the evolution. *Scand J Med Sci Sports*. (2020) 30(6):962–4. doi: 10.1111/sms.13681

4. Nassis GP, Brito J, Tomás K, Heiner-Møller K, Harder P, Kryger KO, et al. Elite women's football: evolution and challenges for the years ahead. *Scand J Med Sci Sports*. (2022) 32(S1):7–11. doi: 10.1111/sms.14094

5. Gabbett TJ. The training—injury prevention paradox: should athletes be training smarter and harder? *Br J Sports Med*. (2016) 50(5):273–80. doi: 10.1136/bjsports-2015-095788

6. Thompson CJ, Smith A, Coutts AJ, Skorski S, Datson N, Smith MR, et al. Understanding the presence of mental fatigue in elite female football. *Res Q Exerc Sport*. (2022) 93(3):504–15. doi: 10.1080/02701367.2021.1873224

7. Pfirrmann D, Herbst M, Ingelfinger P, Simon P, Tug SL. Analysis of injury incidences in male professional adult and elite youth soccer players: a systematic review. *J Athl Train*. (2016) 51(5):410–24. doi: 10.4085/1062-6050-51.6.03

8. Hannon MP, Colemnn MP, Parker LJF, McKeown J, Unnithan VB, Close GL, et al. Seasonal training and match load and micro-cycle periodization in male premier league academy soccer players. *J Sports Sci*. (2021) 39(16):1838–49. doi: 10.1080/02640414.2021.1899610

9. Arnold R, Fletcher D. A research synthesis and taxonomic classification of the organizational stressors encountered by sport performers. *J Sport Exerc Psychol*. (2012) 34(3):397. doi: 10.1123/jsep.34.3.397

10. Akenhead R, Nassis GP. Training load and player monitoring in high-level football: current practice and perceptions. *Int J Sports Physiol Perform*. (2016) 11 (5):587–93. doi: 10.1123/ijspp.2015-0331

11. Foster C. Monitoring training in athletes with reference to overtraining syndrome. *Med Sci Sports Exercise*. (1998) 30(7):1164–8. doi: 10.1097/00005768-199807000-00023

12. Jiang Z, Hao Y, Li Y. A systematic review of the relationship between workload and injury risk of professional male soccer players. *Int J Environ Res Public Health*. (2022) 19(20):13237. doi: 10.3390/ijerph192013237

13. Nédélec M, Halson S, Abaidia A-E, Ahmaidi S, Dupont G. Stress, sleep and recovery in elite soccer: a critical review of the literature. *Sports Med*. (2015) 45 (10):1387–400. doi: 10.1007/s40279-015-0358-z

14. Martínez-González N, Atienza FL, Tomás I, Duda JL, Balaguer I. The impact of coronavirus disease 2019 lockdown on athletes' subjective vitality: the protective role of resilience and autonomous goal motives. *Front Psychol*. (2021) 11(4061):612825. doi: 10.3389/fpsyg.2020.612825

15. Schmitt M, Blum GS. State/trait interactions. In: Zeigler-Hill V, Shackelford TK, editors. *Encyclopedia of personality and individual differences*. Cham: Springer International Publishing (2020). p. 5206–9.

16. Jeppesen P, Obel C, Lund L, Madsen KB, Nielsen L, Nordentoft M. *Mental sundhed og sygdom hos børn og unge i alderen 10–24 år—forekomst, fordeling og forebyggelsesmuligheder*. København: Vidensråd for Forebyggelse (2020). 1–359.

17. Dohlsten J, Barker-Ruchti N, Lindgren E-C. Sustainable elite sport: Swedish athletes' voices of sustainability in athletics. *Qual Res Sport Exerc Health*. (2021) 13 (5):727–42. doi: 10.1080/2159676X.2020.1778062

18. Kuettel A, Melin A, Larsen CH, Lichtenstein MB. Depressive symptoms in danish elite athletes using the major depressive inventory (MDI) and the center for epidemiological studies depression scale (CES-D). *Scand J Sport Exerc Psychol*. (2022) 4(1):1–9. doi: 10.7146/sjsep.v4i1.128360

19. Madsen EE, Krustrup P, Larsen CH, Elbe A-M, Wikman JM, Ivarsson A, et al. Resilience as a protective factor for well-being and emotional stability in elite-level football players during the first wave of the COVID-19 pandemic. *Sci Med Football*. (2021) 5(sup21):62–9. doi: 10.1080/24733938.2021.1959047

20. Saidi K, Abderrahman AB, Boullosa D, Dupont G, Hackney AC, Bideau B, et al. The interplay between plasma hormonal concentrations, physical fitness, workload and mood state changes to periods of congested match play in professional soccer players. *Front Physiol*. (2020) 11:835. doi: 10.3389/fphys.2020.00835

21. Pillay L, Burgess D, van Rensburg DCJ, Kerkhoffs GM, Gouttebarge V. The congested international match calendar in football: views of 1055 professional male players. *BMC Sports Sci Med Rehabil*. (2022) 14(1):200. doi: 10.1186/s13102-022-00597-w

22. Ramboll M. SurveyXact (2021). (Retrieved December 8, 2021).

23. Sideline Sports. (2021). Iceland.

24. Connor KM, Davidson JRT. Development of a new resilience scale: the connor-davidson resilience scale (CD-RISC). *Depress Anxiety*. (2003) 18(2):76–82. doi: 10.1002/da.10113

25. Extremera MO, Moreno EO, Concález MC, Ortega FZ, Ruz RP. Validation of resilience scale (CD-RISC) in elite athletes through a structural equation model. *Federacion Espanola de Associaciones de Docentes de Educacion Fisica (FEADEF)*. (2017) 32:96–100.

26. Cohen S, Kamarck T, Mermelstein R. Perceived stress scale. Measuring stress: a guide for health and social scientists. *Mind Garden*. (1994) 10:386–96.

27. Saidi O, Pereira B, Peyrel P, Maso F, Dorá E, Rochette E, et al. Sleep pattern and staging in elite adolescent rugby players during the in-season competitive phase compared to an age matched non-athlete population. *Eur J Sport Sci*. (2021) 22:1–12. doi: 10.1080/17461391.2021.1887368

28. Organization, W.H. Who-Five Well-being Index (WHO-5) (1998). (cited 2021 Januar 1, 2021).

29. Belz J, Kleinert J, Ohlert J, Rau T, Allroggen M. Risk for depression and psychological well-being in German national and state team athletes—associations with age, gender, and performance level. *J Clin Sport Psychol*. (2018) 12(2):160–78. doi: 10.1123/jcsp.2016-0024

30. Hooper SL, Mackinnon LT. Monitoring overtraining in athletes recommendations. *Sports Med*. (1995) 20:321–7. doi: 10.2165/00007256-199520050-00003

31. Rabbani A, Clemente FM, Kargarfard M, Chamari K. Match fatigue time-course assessment over four days: usefulness of the hooper Index and heart rate variability in professional soccer players. *Front Physiol*. (2019) 10:109. doi: 10.3389/fphys.2019.00109

32. Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, et al. A new approach to monitoring exercise training. *J Strength Cond Res*. (2001) 15 (1):109–15. PMID: 11708692

33. Haddad M, Stylianides G, Djaoui L, Dellal A, Chamari K. Session-RPE method for training load monitoring: validity, ecological usefulness, and influencing factors. *Front Neurosci*. (2017) 11:612. doi: 10.3389/fnins.2017.00612

34. Rollo I, Impellizzeri FM, Zago M, Iaia FM. Effects of 1 versus 2 games a week on physical and subjective scores of subelite soccer players. *Int J Sports Physiol Perform*. (2014) 9(3):425–31. doi: 10.1123/ijspp.2013-0288

35. Howle K, Waterson A, Duffield R. Recovery profiles following single and multiple matches per week in professional football. *Eur J Sport Sci*. (2019) 19 (10):1303–11. doi: 10.1080/17461391.2019.1601260

36. García-Aliaga A, Marquinha M, Roman IR, Solana DM, Piñero Madrona JA, del Campot RL, et al. COVID-19 confinement effects on game actions during competition restart in professional soccer players. *Int J Environ Res Public Health*. (2022) 19 (7):4252. doi: 10.3390/ijerph19074252

37. Krustrup P, Mohr M, Steensberg A, Bencke J, Kjaer M, Bangsbo J. Muscle and blood metabolites during a soccer game: implications for sprint performance. *Med Sci Sports Exercise*. (2006) 38(6):1165–74. doi: 10.1249/01.mss.0000222845.89262.cd

38. Bangsbo J, Mohr M, Krustrup P. Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci*. (2006) 24(7):665–74. doi: 10.1080/02640410500482529

39. Mohr M, Draganidis D, Chatzinikolaou A, Barbero-Ávarez JC, Castagna C, Douroudos I, et al. Muscle damage, inflammatory, immune and performance responses to three football games in 1 week in competitive male players. *Eur J Appl Physiol*. (2016) 116(1):179–93. doi: 10.1007/s00421-015-3245-2

40. Rowell AE, Aughey RJ, Hopkins WG, Stewart AM, Cormack SJ. Identification of sensitive measures of recovery after external load from football match play. *Int J Sports Physiol Perform*. (2017) 12(7):969–76. doi: 10.1123/ijspp.2016-0522

41. de Hoyo M, Cohen DD, Sañudo B, Carrasco L, Álvarez-Mesa A, del Ojo JJ, et al. Influence of football match time–motion parameters on recovery time course of muscle damage and jump ability. *J Sports Sci*. (2016) 34(14):1363–70. doi: 10.1080/02640414.2016.1150603

42. Fullagar HHK, Skorski S, Duffield R, Julian R, Bartlett J, Meyer T. Impaired sleep and recovery after night matches in elite football players. *J Sports Sci*. (2016) 34 (14):1333–9. doi: 10.1080/02640414.2015.1135249

43. Fransson D, Krustrup P, Mohr M. Running intensity fluctuations indicate temporary performance decrement in top-class football. *Sci Med Football*. (2017) 1 (1):10–7. doi: 10.1080/02640414.2016.1254808

44. Noor D, McCall A, Jones M, Duncan C, Ehrmann F, Meyer T, et al. Transitioning from club to national teams: training and match load profiles of international footballers. *J Sci Med Sport*. (2019) 22(8):948–54. doi: 10.1016/j.jsams.2019.02.006

45. Paul DJ, Tomazoli G, Nassis GP. Match-related time course of perceived recovery in youth football players. *Int J Sports Physiol Perform*. (2019) 14(3):339–42. doi: 10.1123/ijspp.2017-0521

46. Gunnarsson TP, Bendiksen M, Bischoff R, Christensen PM, Lesivig B, Madsen K, et al. Effect of whey protein- and carbohydrate-enriched diet on glycogen resynthesis during the first 48 h after a soccer game. *Scand J Med Sci Sports*. (2013) 23(4):508–15. doi: 10.1111/j.1600-0838.2011.01418.x

47. Putlur P, Foster C, Miskowski JA, Kane MK, Burton SE, Scheet TP, et al. Alteration of immune function in women collegiate soccer players and college students. *J Sports Sci Med*. (2004) 3(4):234–43. PMID: 24624008

48. Noor D, McCall A, Jones M, Duncan C, Ehrmann F, Meyer T, et al. Perceived load, fatigue and recovery responses during congested and non-congested micro-cycles in international football tournaments. *J Sci Med Sport*. (2021) 24 (12):1278–83. doi: 10.1016/j.jsams.2021.07.001

49. Delaval B, Abaîdia A-E, Delecroix B, Le Gall F, McCall A, Ahmaidi A, et al. Recovery during a congested schedule and injury in professional football. *Int J Sports Physiol Perform*. (2022) 17(9):1399–406. doi: 10.1123/ijspp.2021-0504

50. Costa JA, Figueiredo P, Lastella M, Nakamura FY, Guilherme J, Brito J. Comparing sleep in shared and individual rooms during training camps in elite youth soccer players: a short report. *J Athl Train*. (2023) 58(1):79–83. doi: 10.4085/1062-6050-0042.22

51. Thun E, Bjornvatn B, Flo E, Harris A, Pallesen S. Sleep, circadian rhythms, and athletic performance. *Sleep Med Rev*. (2015) 23:1–9. doi: 10.1016/j.smrv.2014.11.003

52. Condo D, Lastella M, Aisbett B, Stevens A, Roberts S. Sleep duration and quality are associated with nutrient intake in elite female athletes. *J Sci Med Sport*. (2022) 25 (4):345–50. doi: 10.1016/j.jsams.2021.11.045

53. Randers MB, Mujika I, Hewitt A, Santisteban J, Bischoff R, Solano R, et al. Application of four different football match analysis systems: a comparative study. *J Sports Sci*. (2010) 28(2):171–82. doi: 10.1080/02640410903428525

54. Donaldson SI, Grant-Vallone EJ. Understanding self-report bias in organizational behavior research. *J Bus Psychol*. (2002) 17(2):245–60. doi: 10.1023/A:1019637632584

55. Costa JA, Brito J, Nakamura FY, Figueiredo P, Oliveira E, Rebelo A. Sleep patterns and nocturnal cardiac autonomic activity in female athletes are affected by the timing of exercise and match location. *Chronobiol Int*. (2019) 36(3):360–73. doi: 10.1080/07420528.2018.1545782

56. Moesch K, Kenttä G, Kleinert J, Quinon-Fleuret C, Cecil S, Bertollo M. FEPSAC Position statement: mental health disorders in elite athletes and models of service provision. *Psychol Sport Exerc*. (2018) 38:61–71. doi: 10.1016/j.psychsport.2018.05.013

57. Feddersen NB, Champ F, Sæther SA, Littlewood M. Confidentiality and surveillance challenges for psychologists working in men's football academies in England. *J Appl Sport Psychol*. (2022) 35:1–21. doi: 10.1080/10413200.2022.2134506

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# Injuries in male youth football: a one season prospective cohort study of 223 Danish elite players

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**Objectives:** This study prospectively investigated injury prevalence, incidence, and burden in male elite under-17 football players (*N* = 223) during a full season.
**Methods:** The players weekly completed a standardized web-based injury survey (OSTRC-H2) and a physical exposure report throughout the study.
**Results:** Average weekly response rate was 89.5%. Football exposure accounted for 52.4% of total physical exposure. On average (±SD), the players participated in individual football, strength, and rehabilitation practices for 1.2 ± 1.5, 3.0 ± .2.1, and 1.9 ± 3.4 h/week, respectively. In total, 742 health problems were reported. Mean weekly prevalence of health problems, injuries and illnesses were 20.1%, 16.5% and 3.8%, respectively. The injury incidence per 1,000 h of football exposure, match play and team practice were 8.28 (95% CI: 7.54–9.08), 16.77 (95% CI: 13.65–20.4), and 7.24 (95% CI: 6.5–8.04), respectively. Sudden-onset and gradual-onset injuries accounted for 36.7% and 43.4% of the total proportion of health problems. Hip/groin injuries had the highest incidence (1.58/1,000 h), whereas knee injuries had the highest burden (20.86 days lost/1,000 h). On average, the players experienced 3.33 health problems (average duration: 7.8 days). On average pr. player, 2.7 (95% CI: 2.2–3.3) wks of football exposure were lost.
**Conclusion:** Sudden and gradual-onset injuries influenced player availability during the season. Health problem prevalence fluctuated markedly, and injury incidence was higher during match play than training. The players had substantial volumes of training beyond football-specific training and matches. Our findings could assist medical and sports science practitioneers in enhancing training and recovery processes to maximize player availability.

KEYWORDS

player availability, prevalence, incidence, time-loss, injury burden, OSTRC-H2, health problems, soccer

## Introduction

Despite the many health benefits of sports participation (1), it is also the leading cause of injury among children and adolescents (2). In a recent study involving 3,498 adults and 3,221 children, Danish senior and youth football players had together with handball the highest prevalence of injuries in the past 12 months compared to 49 other sports (3). Injuries sustained during youth may negatively impact player development, well-being,

future performance, and career prospects (4, 5). Also, an increased risk of drop-out and osteoarthritis in later life has been reported (6, 7, 8). Preventing injuries and health problems in youth football is therefore of paramount importance.

An integral first step towards prevention is gaining an understanding of the extent of injuries and illnesses (9). Traditionally, sports injury surveillance research in football has focused on the identification of serious time-loss acute sudden-onset or medical attention injuries. In addition, injury severity has commonly been defined by the duration of time lost as a proxy measure using a medical staff, athletic trainers or non-medical staff for injury reporting (10, 11). Consequently, little is known about other injury types (e.g., non-traumatic injuries or those that do not result in time-loss or medical attention) as well as the consequences of injury besides time-loss.

Recent technological and methodological advances have resulted in new opportunities to measure sport-related injury using player self-reports (10, 12). OSTRC Overuse Injury Questionnaire was developed to identify the occurrence of overuse injuries and their consequences. This represents an important step in injury epidemiology as it identifies many injuries missed with traditional approaches.

The updated Oslo Sport Traumatic Research Center questionnaire on Health Problems (OSTRC-H2) serves as an injury surveillance method with a broader focus on health problems (13). This tool was recently employed to assess the efficacy of a load management intervention on injury risk in young elite football players (14), to prospectively monitor injury incidence within a single football academy (15), and to describe prevalence and burden of injuries and illnesses in Japanese men's university football players (16). Recent research indicates, that youth elite football players are at an increased risk of health problems during periods of rapid growth and maturation (17). Additional research suggest that the incidence of time-loss injuries and injury burden could be especially high in age groups below the age of 17 (18). However, to our knowledge, no studies have yet used the OSTRC-H2 method to examine the prevalence and burden of health problems in young elite football players who are under the age of 17 across multiple clubs. Conducting a large scale study could be especially important as previous studies suggest that the injury pattern in youth players, as opposed to elite adult players, may be characterized by a higher frequency of gradual-onset injuries (17).

Thus, the present study aimed to prospectively investigate the prevalence, incidence, and burden of health problems in a group of male youth elite football players competing in the Danish under-17 premier league over a full competitive season, utilizing the OSTRC-H2.

# Materials and methods

## Study design, recruitment, and ethical considerations

The study was conducted as a prospective one-season cohort study on male youth elite football players (age: 15–17 yrs.). The procedures in this study were parts of a comprehensive investigational protocol (The National Danish Male Youth Elite Football Study) initiated by The Danish League exploring injury pattern as well as changes to physical and psychological performance during a full competitive season in male youth football. The participating players were prior to the beginning of the study period selected for the 1st team player rooster of a Danish male under-17 premier league club by others. The players self-reported weekly health problems using the OSTRC-H2 (13) as well as training and match exposure during the 2021/22 in-season playing period including the mid-season break. Players were recruited through initial official contacts to the front office of all clubs competing in the male Danish under-17 premier league. Individual inclusion criteria were selected as follows: male youth elite football player included in the 1st team under-17 player rooster in a football club competing in the Danish under-17 premier league during the 2021/22 season. The exclusion criteria were selected as: not accepting participation in the study, and not being willing to adhere to all protocol procedures throughout the investigation period. Players provided written informed consent to participate in the study, with the informed consent form being signed by a parent/legal guardian. The study was reviewed and approved by the local ethic committee (Ethic Committee of Southern Denmark, Identifier: 20212000–89).

## Health problem and injury definitions

In accordance with the International Olympic Committee (IOC) consensus statement on method for recording and reporting epidemiological data in sports, and the football-specific extension of the IOC consensus statement (19, 20) a health problem was defined as: "*Any condition that reduced a player's normal state of complete health, irrespective of its consequences on football participation or performance, or whether the player sought medical attention*". Health problems were classified into injuries and illnesses. An injury was defined as a tissue damage or other derangement of normal physical function. An illness was defined as a complaint or disorder experienced by a player, not related to injury. Injuries were further classified by mode of onset. A sudden-onset injury was defined as a single, clearly identifiable energy transfer. A gradual-onset injury was defined as multiple accumulative bouts of energy transfer without a single, clearly identifiable event being responsible for the injury (19). A time-loss related health problem was defined as a time-loss health problem leading to a player not being able to fully participate in a planned training session or match play (19). As per the football-specific extension of the IOC consensus statement, injury burden was defined as the number of days lost per 1,000 h of football exposure (20).

Football exposure was defined as the total hours of team training and matches, with team training exposure defined as the total number of hours of specific football training team practice. This included all team sessions involving the techniques and/or tactics of football. A match was defined as organized and scheduled match play against an opposing team (including

official matches, friendlies and junior/reserve team matches and international matches) (19).

## Data collection

Player characteristics (age, height, weight and playing position) were collected at baseline prior to study start by club sports science sector staff members following standardized procedures. Player characteristics were subsequently reported to the study leaders.

For a total of 45 weeks during the 2021/2022 season (August 2021 - June 2022), players reported any health problems experienced during the preceding 7 day period by completing the OSTRC-H2 (13) using a mobile application (AthleteMonitoring.com, FITSTATS Technologies Inc., Moncton, Canada) at the end of each week (Sunday at 7 p.m.). The standards and procedures of the OSTRC-H2 has previously been described (12). In brief, the OSTRC-H2 is based on four key questions (**Figure 1**) related to the difficulties in training and football participation (Q1, response options: 1 = full, 2 = full with a health problem, 3 = reduced with a health problem, 4 = absent due to a health problem), the extent to which participation was modified (Q2, response options: 1 = no modification, 2 = minor extent, 3 = moderate extent, 4 = major extent), the extent a health problem affected performance (Q3, response options: 1 = no effect, 2 = minor

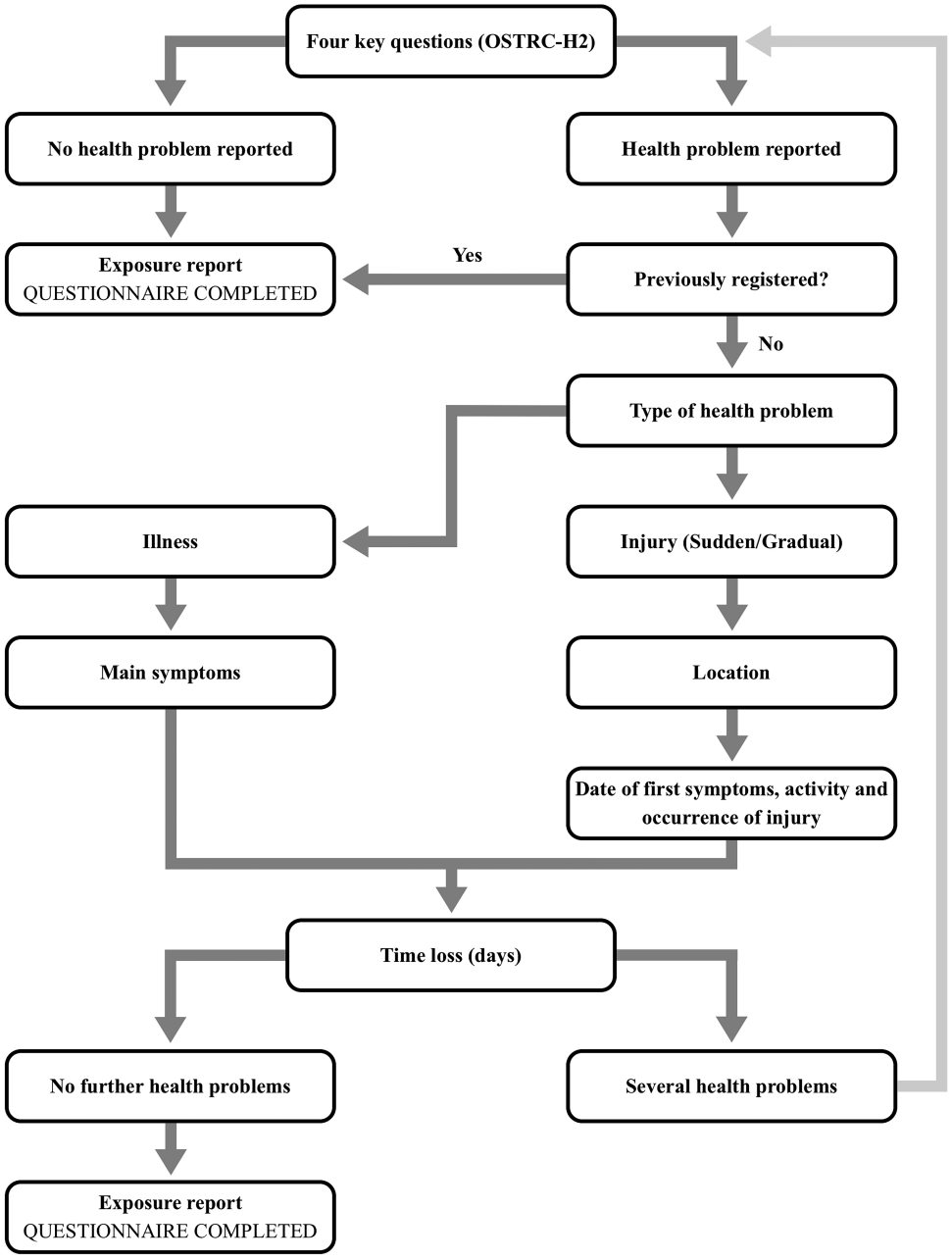


FIGURE 1
Weekly injury survey application logic. Diagram modified from Clarsen et al. (2013).

extent, 3 = moderate extent, 4 = major extent), and the extent of experienced symptoms/complaints (Q4, response options: 1 = no symptoms/complaints, 2 = mild extent, 3 = moderate extent, 4 = severe extent). Based on the responses to these questions, health problems were classified into any health problems (responses above 1 to Q1) or substantial health problems leading to a moderate or severe reduction in training volume or a moderate or severe reduction in sports performance (responses 3 or 4, respectively, for Q2 and Q3) (12). A time-loss injury was registered in the case players selected option 4 in Q1.

After completing the OSTRC-H2, the players reported their individual total weekly physical exposure over the last week by answering the following five question; 1) "*How many hours did you in total dedicate to team practice (not matches)?*", 2) "*How many hours did you in total dedicate to self-practice and individual practice with the ball (not team practice)?*", 3) "*How many hours did you in total dedicate to strength training including injury prevention?*", 4) "*How many hours did you in total dedicate to self-practice and individual practice without the ball (not strength or injury prevention)?*", 5) "*How many hours did you in total dedicate to rehabilitation from an injury or a health problem (all types of training)?*".

The players were orally and in writing instructed on all technical matters related to the reporting process. At least one staff member at each club was assigned to support the players throughout the study period. To enhance individual response rates, the research team utilized a follow-up system in which individuals who did not complete the OSTRC-H2 or the individual exposure report on time received a text push-message. Also, a dedicated club staff member contacted them personally.

The team training and match exposure was cross-checked by evaluating micro-cycle training plans provided by the coaching staff, which were sent via e-mail to the study personnel in a pre-formatted Excel spreadsheet. Individual match exposure was confirmed by examining official match reports provided the Danish league association. All exposure values were reported weekly with the precision of 0.5 h, except match exposure which was reported with a precision of 1 min. **Figure 1** illustrates the question logic of the weekly survey.

## Statistical analysis

The cumulative severity scores for all health problems were summed, with the proportion of the total burden of health problems made up by the number of illnesses and injuries (10). The weekly prevalence of health problems (e.g., injury and illness) was determined by dividing the number of players reporting any form of health problem by the number questionnaire respondents (12). The prevalence of substantial health problems was calculated using the same approach. The weekly prevalence of health problems and substantial health problems was reported as average percentages with 95% confidence intervals (95% CI). To assess player availability, the prevalence of each degree of participation was determined by calculation the number of players reporting each type of participation degree by the number of questionnaire respondents. The degree of participation was lead from OSTRC-H2 Q1, which divided the degree of participation into four categories: "*Full participation without any health problem*", "*Full participation, but with a health problem*", "*Reduced participation due to a health problem*", or "*Could not participate due to a health problem*" (13). Injury incidence was expressed as the number of injuries per 1,000 h of both football team training and match play (football exposure) (21). Injury incidence was reported as mean values with 95% confidence intervals (95% CI). Mean injury burden was calculated as the number of injury days lost per 1,000 h (injury incidence multiplied by mean absence per injury divided by 1,000), accounting for both the frequency and severity of injuries (21). No attempts to impute missing health data were performed. Periods of vacation (e.g., winter break off-season period and periods during which the players had no planned training or matches) were considered a part of the total yearly macro-cycle and included for analysis (22). Duplicate OSTRC-H2 reports were excluded. All statistical analyses were conducted in Stata V.17.0 software (StataCorp, College station, TX, US).

# Results

## Participants

Twelve out of fourteen eligible clubs agreed to participate in the study. In total, 292 players were individually invited to participate in the study, with 223 players included for final analysis (**Figure 2**). In total, 18 players were excluded due to an insufficient response rate, with the average response rate for the excluded players being 5.55 ± 0.0% (mean ± SD). During the study period, 8 players were additionally transferred to clubs outside the scope of present investigation, and 11 players were transferred to older age-group teams. These players were excluded from the final analysis. Furthermore, 32 players left the study within study period with reason ($N = 15$) or no reason ($N = 17$) provided. Baseline player characteristics are reported in **Table 1**. The mean weekly response rate during the study was 89.5% (95% CI 87.1 to 92.0).

## Physical exposure

Total football exposure and training distribution are presented in **Table 2**. Football exposure accounted for more than half of the total yearly exposure time. Training activities conducted to increase strength qualities and reduce injury risk accounted for around 25% of total yearly exposure. Individual training with and without the ball and time dedicated to rehabilitations purposes accounted for approximately 25% of total yearly exposure.

## Health problems

During the 45-week study period, a total of 742 health problems were reported. Based on severity score, injuries accounted for 80.2% of the total proportion of health problems

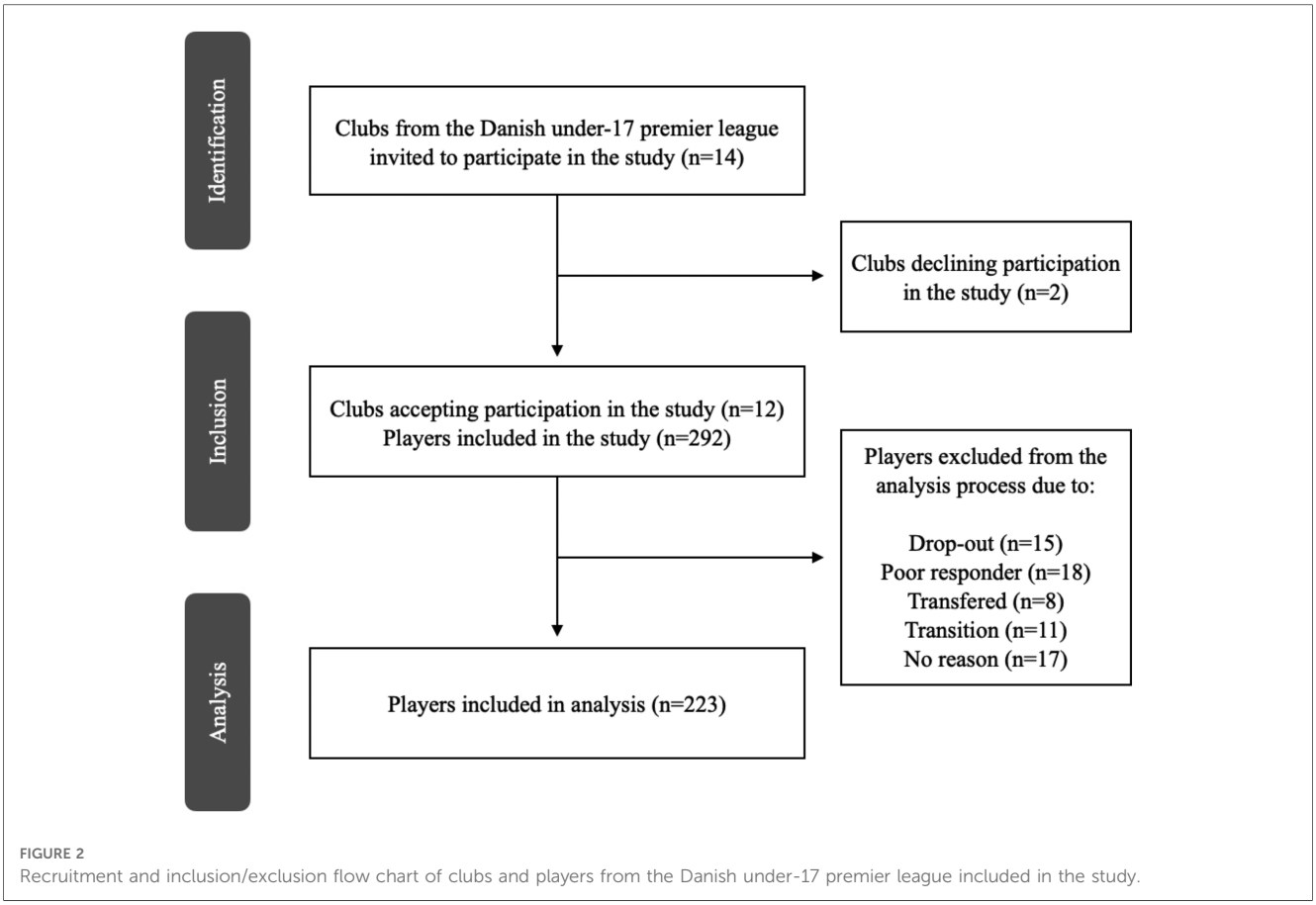


FIGURE 2
Recruitment and inclusion/exclusion flow chart of clubs and players from the Danish under-17 premier league included in the study.

(60.7% of all health problems). Sudden-onset and gradual-onset injuries accounting for 36.7% and 43.4% of the total proportion of health problems, respectively (28.0% and 32.7% of all cases, respectively). Lower extremity injuries accounted for 67.4% of the total proportion of injuries (equivalent to 51.6% of the total number of injuries). Illnesses accounted for 19.8% of the total proportion of health problems (39.2% of all reported health problems). Respiratory illness had the highest no. of illnesses ($N$ = 126) (weekly average: 2.7 ± 2.6 cases), followed by COVID-19 ($N$ = 82: weekly average: 1.8 ± 4.5 cases) (Table 3). On average, a player had 3.33 health problems throughout the study period, with an average duration of 7.8 days per health problem.

TABLE 1 Player characteristics ($N$ = 223).

| Player characteristics, mean (SD) | |
|---|---|
| Age, years | 15.6 ± 0.6 |
| Height, cm | 179.5 ± 6.4 |
| Weight, kg | 67.1 ± 7.8 |
| BMI, kg/m$^2$ | 20.7 ± 1.6 |
| Playing position, $n$ (%) | |
| Goalkeeper | 21 (9.41) |
| Central defender | 39 (17.49) |
| Full-back/Wing-back | 46 (20.63) |
| Central midfielder | 53 (23.77) |
| Wide midfielder/Wing | 36 (16.14) |
| Striker/Central forward | 28 (12.56) |
| Team, mean (SD) | |
| Size | 19.3 ± 2.6 |

## Injury prevalence

The mean weekly prevalence of health problems, injuries and illnesses were 20.1%, 16.5% and 3.8%, respectively. Sudden-onset and gradual-onset injuries accounted for 34.8% and 47.8% of the total injury prevalence. Mean weekly prevalence of all health problems, as well as health problems of substantial and time-loss character, is reported in Table 4. During the study period, fluctuations in health problem, injury and illness prevalence were observed (Figure 3).

## Injury incidence and injury burden

The injury incidence rate was 8.28 (95% CI: 7.54 to 9.08) per 1,000 h of football exposure, with injury incidence rate for team training and match play being 7.24 (95% CI: 6.50 to 8.04) and 16.77 (95% CI: 13.65 to 20.4) per 1,000 h of football exposure, respectively, resulting in a match play to team training incidence rate ratio of 2.3. All injuries sustained during matches ($N$ = 100) were categorized as having a sudden-onset, whereas the injury incidence in training for sudden-onset and gradual-onset was 2.23 (95% CI: 1.83 to 2.69) and 5.01 (95% CI: 4.4 to 5.68) per

TABLE 2 Weekly average and total exposure values per player during the 45-week study period ($N = 223$). Data are presented as mean ± SD. Yearly distribution is presented as percentage with 95% confidence intervals.

| | Weekly average | | | Total | | | Yearly Distribution (%) | |
|---|---|---|---|---|---|---|---|---|
| **Football exposure** | | | | | | | | |
| - Total football exposure (hours) | 6.05 | ± | 3.32 | 243.85 | ± | 74.98 | 52.44 | (50.53 to 54.35) |
| - Team training exposure (hours) | 5.39 | ± | 3.02 | 217.14 | ± | 69.93 | 46.48 | (44.80 to 48.16) |
| - Match play exposure (hours) | 0.66 | ± | 0.78 | 26.70 | ± | 12.89 | 5.96 | (5.53 to 6.38) |
| **Football related exposure** | | | | | | | | |
| - Individual self-practice with ball exposure (hours) | 1.18 | ± | 1.54 | 47.47 | ± | 33.95 | 9.66 | (8.89 to 10.43) |
| **Strength training and injury prevention exposure** | | | | | | | | |
| - Strength training and injury prevention exposure (hours) | 2.99 | ± | 2.1 | 120.39 | ± | 56.87 | 24.48 | (23.50 to 25.47) |
| **Other activities** | | | | | | | | |
| - Rehabilitation and generic training activities (hours) | 1.88 | ± | 3.35 | 75.92 | ± | 102.95 | 13.42 | (11.72 to 15.12) |

1,000 h of exposure, respectively. Hip/groin injuries had the highest incidence rate of 1.58 (95% CI: 1.26 to 1.95) per 1,000 h of football exposure, while knee injuries had the highest injury burden with 20.86 days lost per 1,000 h of football exposure. Elbow and head injuries resulted in the highest mean time-loss days of all body regions, with a mean of 35.0 ± 0.0 ($N = 1$, hence no SD) and 22.1 ± 53.95 days lost per injury, respectively. Injury incidence and burden are presented in Table 5. Risk matrixes displaying the overall incidence and severity of injuries for each body region is presented in Figures 4 and 5.

## Player availability

The mean weekly proportion of players able to fully participate in football with or without a health problem during the study period was 84.9% (95% CI: 83.5 to 86.3). The average weekly proportion of players who were able to participate fully but had a health problem was 5.04% (95% CI: 4.48 to 5.6). During the study period the mean weekly proportion of players fully unable to participate in any football activities was 6.6% (95% CI: 5.9 to 7.3). On average, the number of weeks a player was unable to participate in any football activities was 2.7 (95% CI: 2.12 to 3.24) during the study period. The player availability during the full study period is presented in Figure 6.

# Discussion

During a full playing season, our study prospectively investigated health problems in Danish male youth elite football players. A major finding is, that the injury pattern of young elite football players below the age of 17 years resembled that of adult level professional players (6). As such, lower extremity sudden-onset and gradual-onset injuries was shown to be the main causes of missed team practice and match play. Furthermore, knee and head injuries displayed the highest burden and had the most days lost per injury, respectively. Also, a higher injury incidence rate per 1,000 h was observed during match play compared to team practice. Another finding of the study is, that the weekly prevalence of health problems fluctuated over the time-course of the study. This indicates that injury risk in youth footballers may be different at various stages during a playing season. In addition, the current study reveals, that young football

TABLE 3 Illnesses in danish male elite youth football players ($N = 223$) during the 45-week study period.

| Categories | No. of illnesses | Weekly average |
|---|---|---|
| Cardiovascular | 1 | 0.02 (0.15) |
| Gastrointestinal | 23 | 0.49 (0.7) |
| Respiratory (upper and lower) | 126 | 2.74 (2.66) |
| Dental | 0 | 0.0 (0) |
| Neurological | 6 | 0.12 (0.32) |
| Otological | 1 | 0.02 (0.15) |
| Urogenital | 0 | 0.0 (0) |
| Psychological | 0 | 0.0 (0) |
| Dermatological | 0 | 0.0 (0) |
| Ophthalmological | 0 | 0.0 (0) |
| Nonspecific | 21 | 0.44 (0.78) |
| Unknown | 31 | 0.68 (0.82) |
| COVID-19 | 82 | 1.79 (4.54) |
| Musculoskeletal, rheumatological, and connective tissue (unrelated to injury). | 0 | 0.0 (0) |
| Total | 291 | 6.31 (5.69) |

TABLE 4 Weekly health problem prevalence in danish male elite youth football players ($N = 223$). Values are presented as mean percentages with 95% confidence intervals (CI). .

| | Mean (95% CI) | |
|---|---|---|
| All health problems | 20.13% | (18.50–21.76%) |
| Injuries | 16.48% | (15.28–17.68%) |
| Sudden-onset injuries | 7.01% | (6.38–7.64%) |
| Gradual-onset injuries | 9.63% | (8.70–10.55%) |
| Illness | 3.83% | (2.82–4.83%) |
| Substantial health problems | 13.65% | (12.45–14.85%) |
| Injuries | 10.89% | (10.04–11.73%) |
| Sudden-onset injuries | 5.13% | (4.57–5.70%) |
| Gradual-onset injuries | 5.80% | (5.13–6.47%) |
| Illness | 2.91% | (2.06–3.77%) |
| Time-loss health problems | 6.59% | (5.88–7.29%) |
| Injuries | 5.58% | (5.01–6.16%) |
| Sudden-onset injuries | 3.07% | (2.64–3.51%) |
| Gradual-onset injuries | 2.53% | (2.08–2.98%) |
| Illness | 1.05% | (0.58–1.53%) |

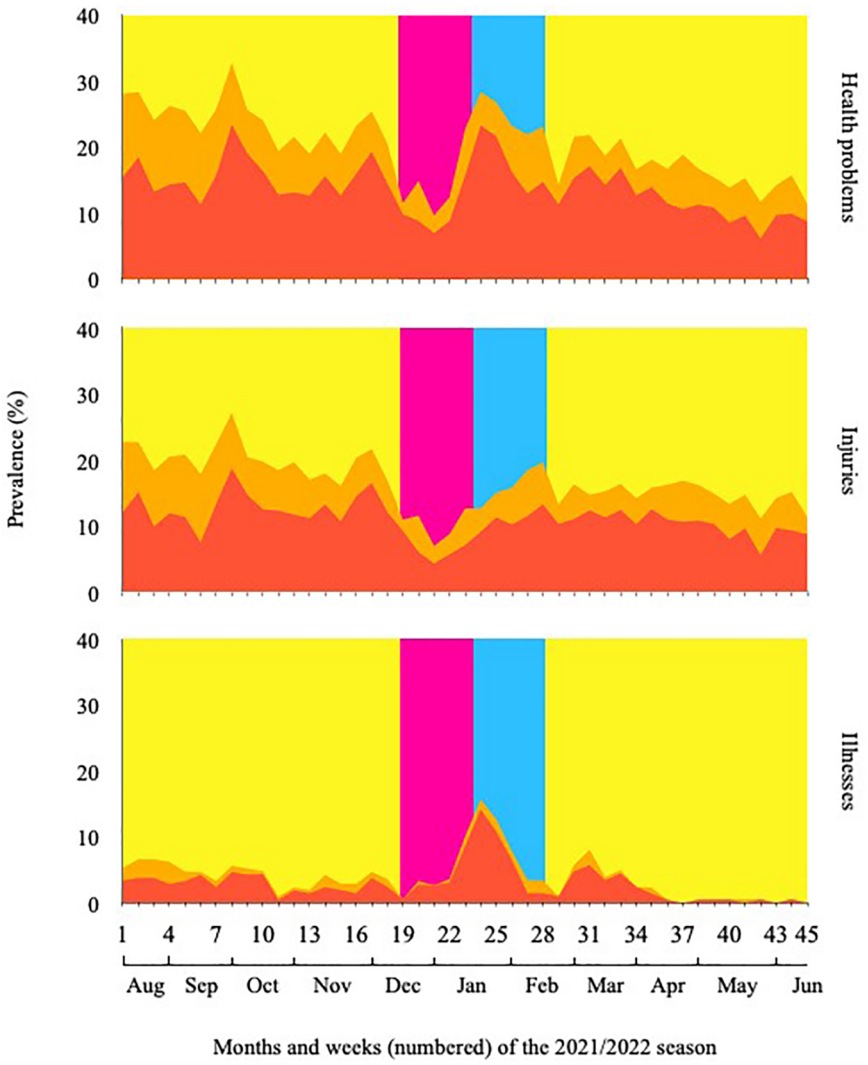


FIGURE 3
Weekly health problem (top), injury (mid), and illness (bottom) prevalence during the 45-week study period. Graph orange area: any complaint. Graph red area: substantial problem. Background color indication: Blue area = pre-season, Yellow area = in-season, Green area = mid-season winter break.

players take part of a significant number of weekly supportive activities (i.e., strength training, self-practice etc.). This finding suggests that football exposure *per se*, may not reflect the actual physical load of contemporary youth elite football.

The total injury incidence rate in elite youth football players is in our study 8.3 injuries per 1,000 h of football exposure. This is higher compared to estimates (6.19 injuries/1,000 h) presented in a recent meta-analysis (23), and lower than reported for similar age-group players from the Netherlands (10.1 injuries/1,000 h) and Qatar (17.0 injuries/1,000 h (18, 24). These discrepancies may be related to differences in study designs, clubs, age-groups, and to individual training and match exposure. In our study, a broader definition of health problems was applied. This is suggested to potentially reveal more health problems (e.g., minor injuries, mild illness symptoms, and mental health issues) compared to other methods (19). Furthermore, the current investigation was conducted across several clubs, each applying a unique approach to player development (25). In addition, the average weekly football exposure in the present study was comparable to that recently demonstrated in under-19 international level players (26). Lastly, the players weekly conducted several hours of non-coach lead practice (**Table 2**). Collectively, this may influence our results compared to other studies.

The burden of injuries during the study period is 87 time-loss days per 1,000 h of football exposure (**Table 5**). This is low when compared to well-trained youth players (425 and 316 injury days/1,000 h of football exposure for U16 and U17 male elite football players, respectively) (18). It is reasonable to suggest, that youth elite footballers generally have access to necessary resources such as equipment, comprehensive medical support, and expert coaches with the ability to control match and training load. Therefore, the reason for this discrepancy is not clear. However, several teams recruited for the present investigation competed at international level standards. As such, it is possible that we have included players who are more experienced, stronger, physically fit, and thus more resistant to injuries.

TABLE 5: Injury number, Incidence rate, time-loss, and burden per body region. Total and mean values related to injury incidence rates are presented with 95% confidence intervals (CI). Values related to the specific body regions and total values are presented as absolute values. Total and mean values related to time-loss days are presented with mean (SD).

| Body region | No. of injuries | Incidence rate, injuries / 1,000 h | Time-loss days | Burden, Time-loss days / 1,000 h |
|---|---|---|---|---|
| Head | 10 | 0.18 (0.09 to 0.34) | 22.1 (53.95) | 4.06 |
| Neck | 3 | 0.05 (0.01 to 0.16) | 3.33 (2.52) | 0.18 |
| Shoulder | 4 | 0.07 (0.02 to 0.19) | 1.0 (2) | 0.07 |
| Elbow | 1 | 0.02 (0.0 to 0.1) | 35.0 (0) | 0.64 |
| Forearm | 1 | 0.02 (0.0 to 0.1) | 0.0 (0) | 0.0 |
| Wrist and hand | 13 | 0.24 (0.12 to 0.41) | 7.77 (8.98) | 1.85 |
| Chest and upper back | 2 | 0.04 (0.0 to 0.13) | 1.5 (2.12) | 0.05 |
| Abdomen | 1 | 0.02 (0.0 to 0.1) | 9.0 (0) | 0.16 |
| Lower back | 26 | 0.48 (0.31 to 0.7) | 14.15 (19.94) | 6.76 |
| Pelvis | 27 | 0.49 (0.33 to 0.72) | 14.26 (29.4) | 7.07 |
| Hip/groin | 86 | 1.58 (1.26 to 1.95) | 8.46 (15.92) | 13.37 |
| Thigh | 63 | 1.16 (0.89 to 1.48) | 8.17 (15.47) | 9.46 |
| Knee | 80 | 1.47 (1.16 to 1.83) | 14.2 (22.22) | 20.86 |
| Lower leg | 25 | 0.46 (0.3 to 0.68) | 12.76 (31.49) | 5.86 |
| Ankle | 61 | 1.12 (0.86 to 1.44) | 7.72 (9.51) | 8.65 |
| Foot | 41 | 0.75 (0.54 to 1.02) | 9.41 (15.84) | 7.09 |
| Unspecified | 7 | 0.13 (0.05 to 0.26) | 2.95 (7.8) | 0.88 |
| Total | 451 | 8.28 (7.54 to 9.08) | 10.69 (18.5) | 87.04 |

In this study, gradual-onset injuries account for 43.4% of the total proportion and 32.7% of all health problems, respectively. In youth football, between 10 and 40% of all injuries are reported to be the result of gradual-onset (27), with differences in definitions being a major contributor to this considerable variation. Our findings are comparable to that in adult elite

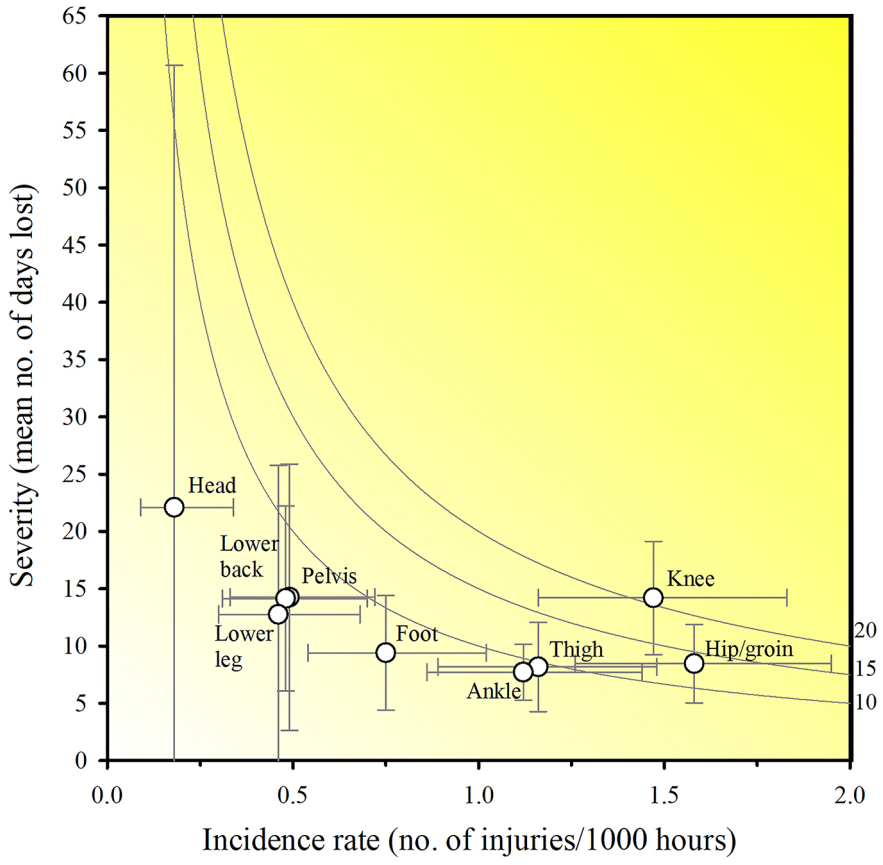


FIGURE 4
Risk matrix based on Oslo Sports Trauma Research Center questionnaire on health problems. Mean time-loss days illustrating the burden of injuries. Error bars represent 95% CIs. Incidence calculations are based on the total football exposure. A darker shade represents a greater burden with isobars indicating equal burden lines.

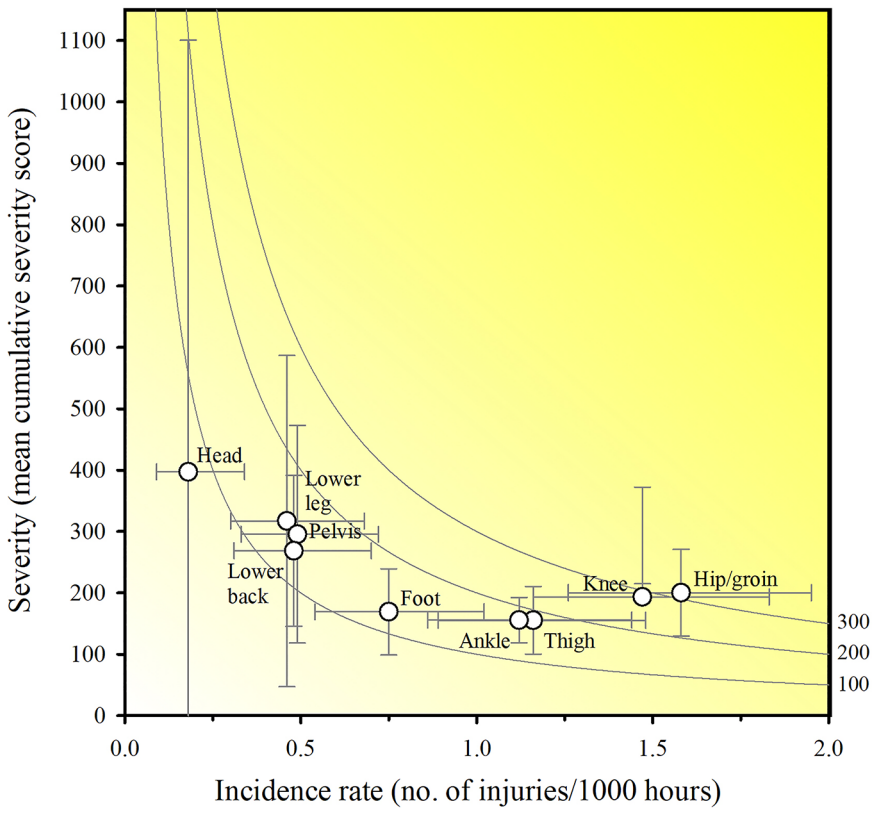


FIGURE 5
Risk matrix based on Oslo Sports Trauma Research Center questionnaire on health problems. Mean cumulative severity scores illustrating the burden of injuries. Error bars represent 95% CIs. Incidence calculations are based on the total football exposure. A darker shade represents a greater burden with isobars indicating equal burden lines.

players, whereas a markedly higher match injury incidence rate is consistently reported for adults (28). It is an unexpected finding in our study, that all match injuries are reported as being of sudden-onset nature. As such, difficulties in assessing the underlying cause behind an injury may influence our results (29). Alternatively, players with pre-match clinical signs of over-use may have been excluded from match participation after medical examination. Also, the types of gradual-onset injuries appear to be age-dependent, with tendinopathies and growth-related conditions being more prevalent in young players. For example, Osgood-Schlatter disease is a common major injury peaking in the under-13 and under-14 age groups, whereas Sever's disease is most frequent in the under-11 age group (30). Although previously established (18), sudden-onset injuries may thus not always differentiate under-17 youth and adult elite football players (5). Finally, a significant proportion (23,6%) of the players were either excluded or left the study, with the remaining players upholding a high response rate throughout the study period. As such, selection bias is likely to have influenced our findings.

In our study, a significant proportion of all reported health problems are related to injuries in the lower extremity. This is in alignment with previous reports on youth elite football (5, 31, 32). The physical demands of elite youth football include high-intensity runs, frequent tackling situations and exposure to collisions and contacts (33). This is believed to increase lower extremity injury risk (27). Also, we report a higher match injury and sudden-onset injury incidence per 1,000 h of exposure compared to team practice. A more pronounced accumulation of physical fatigue as well as an increased number of contacts and collision may influence injury incidence rates during matches (34). Furthermore, a decreased predictability of specific game situations when facing opposing teams may substantially increase match play injury risk (35).

Knee injuries display the highest burden in this study. Knee injuries represent 17% (7%–23%) of all injuries in male youth players (32). In addition, one-third are reported to be due to poor knee function and to occur without contact (36, 37). It has previously been shown that 10–15 min of neuromuscular training 2–3 times weekly reduces non-contact injuries by 45% in youth football players (38). However, although the provision and application of injury treatment and rehabilitation services appears to be adequate in elite football, the provision of injury prevention services is not (39). Therefore, medical and sports science staff may benefit from revising their injury prevention strategies and placing more emphasis on the most burdensome injuries.

Elbow and head injuries have the most time-loss days per injury in present study. Head injury incidence rate in football (soccer) is commonly reported to be low (40) and comparable to

our current findings (10 injuries; 0.1 injuries/1,000 h). However, head injuries may substantially impair a youth player's ability to perform at the elite level. Head injuries may also be subjected to inconsistencies in the interpretation and reporting of the symptoms and are hence frequently underdiagnosed (41). As such, future prospective studies using accurate definitions, recognition, and report on this type of injury are needed to comprehensively study the incidence of concussions among youth footballers. In this study, a single elbow injury (due to a fracture) sustained during a match was reported (**Table 5**). Fractures represent 4% of all injuries in elite football, with 23% of traumatic football fractures occurring in the upper extremity in professional players. Match-play related fracture incidence rate has been reported to be 12-times higher than training fracture incidence rate. This may be explained by differences in playing intensities between training and matches (42). Mean time to return to football after a proximal forearm fracture has been reported to be 5.3 wks (43). As such, fractures, despite their relatively low representation, denote one of the most serious injuries incurred by football players, and account for the most time to recover post-injury. This is confirmed by our findings.

Visual inspections reveal marked fluctuations in health problem, injury, and illness prevalence (**Figure 3**) during the study period with concomitant variability in player availability (**Figure 5**). Also, health problems, injury, and illness prevalence appear to decrease during the latter part of the study period compared to the former. Several factors may explain these findings. Our study included young players from elite football academies. During their academy training, players undergo several phases of transitioning from one playing level or team to the next. These transitions usually occur after the summer break and are often characterized by changes in coaching and support staff, squad composition, training processes, and playing intensities. In fact, football players may not always acquire the necessary levels of fitness during preseason conditioning to resist the load associated with playing competitive football (4). Consequently, the above may have influenced the risk of illnesses as well as of sudden-onset and gradual-onset injury at the beginning of the study period (32). Throughout the duration of the study period, the players dedicated a substantial amount of time to strength/power training and injury prevention activities (**Table 2**). It is thus reasonable to speculate, that the players may have adapted to the level and intensity of football exposure and reduced their risk of injury. Alternatively, the coaching staff may have adjusted the training processes to better align with the players' capacities as the players were exposed to a significant amount of football activities on a weekly basis. Lastly, it is important to acknowledge that the decline observed may potentially be attributed to player responder fatigue.

Using time-loss as a single measure of injury severity to assess health problem burden, may underrepresent gradual-onset injuries and fail to address the most important injuries (19). Our study presents risk matrices to identify the importance of each football-related injury (**Figures 4** and **6**). This approach shows injuries located to the knee to be the most burdensome in our study. Knee injuries alongside ankle, thigh and hip/groin injuries have consistently been reported to have a high prevalence in football (23). In youth football, lower extremities injuries represent about four out of five injuries with thigh, ankle, knee, and hip/groin injuries accounting for 25% (range: 11%–39%), 18% (range: 9%–31%), knee 17% (range: 7%–23%), and 14% (2%–33%) of all injuries, respectively (32). However, isolated proportions for body

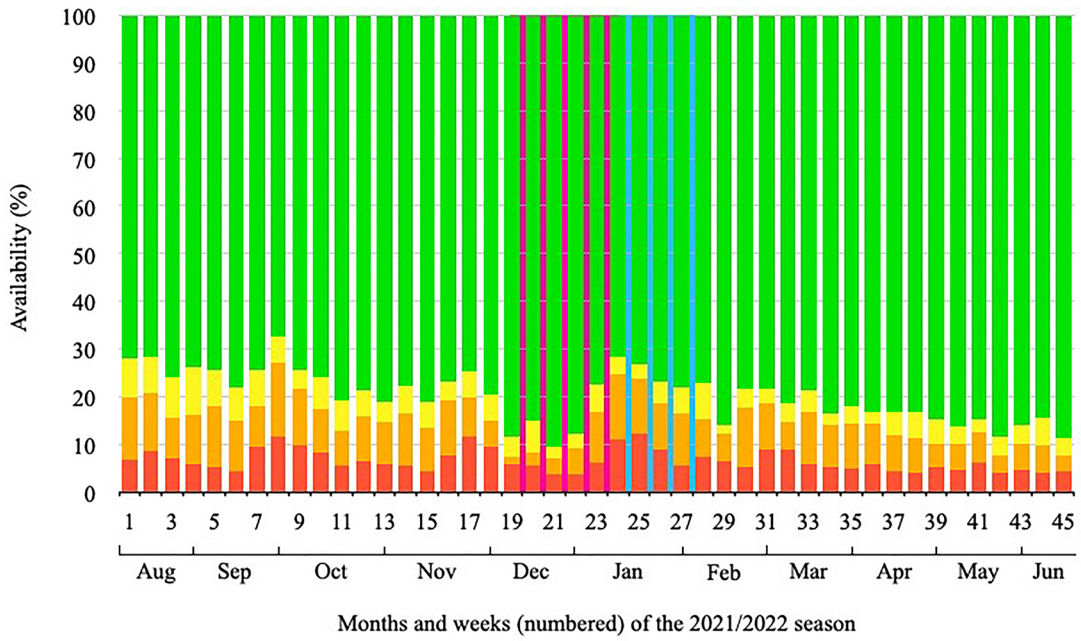


FIGURE 6
Weekly player availability (%) during the 45-week study period. Green area = full participation, yellow area = full participation but with a health problem, orange area = reduced participation due to a health problem, red area = no participation due to a health problem.

parts and types are of limited value since they do not consider injury severity. Reporting injury burden (i.e., days lost for combinations injury types) may therefore represent an advancement in our understanding (44). For instance, in a study of male academy football players, thigh muscle injuries were the most frequent (16% of all injuries, accounting for 11% of total time-loss), whereas joint sprains to the knee had the greatest impact on player availability (3% of injuries and 18% of total time-loss) (18). This information is lost if severity is not accounted for. Therefore, using more measures of health problem severity may provide additional insight, and the information could potentially help practitioners improve the injury-prevention measures used.

Weekly throughout the study period, on average 84.91% (95% CI: 83.5 to 86.32) of all players were able to fully participate in football without or with only a minor health problem. Hence, the player availability in this study is comparable to previous findings reporting an overall player availability of 82.7% in youth academy players (18). Assuming a team size of 20 players, 17 players should at any given time point during the season be available for full participation in practice or matches. In addition, two players should be expected to participate at a reduced level, whereas one player should not be able to participate due to an injury or illness. Being able to participate (i.e., having more football exposure), is suggested as a factor for development success in professional football (45). As presented in this study, a youth elite football player must expect to be unable to participate for on average 2.7 weeks per season. Extending this, although injury incidence rates and time-loss may vary greatly, approximately 4 months of health problem related time-loss must be accounted for during a six year-long academy career. Being away from football for more than 28 days due to a severe injury has been suggested to affect playing skills, long-term development, health outcomes, and future career opportunities significantly (4, 46). As such, introducing effective measure to secure a safe and timely return to football after an injury should be a main priority for football academy medical and sports science practitioneers to optimize player development.

This study took place during the later stages of the COVID-19 pandemic, with the prevalence of COVID-19 remaining at a low level throughout the study period. Also, it is worth mentioning that nearly 80% of all COVID-19 positive tests were reported immediately after the mid-season winter break. Therefore, the impact of COVID-19 on our results may be considered negligible, although the long-term relationship between COVID-19 and changes in injury risks among elite football players is only sparsely investigated (47).

Several limitations apply to our study. For instance, our study includes self-reported football exposure which may introduce measurement errors. However, collecting data through athlete management systems (questionnaire collection) may actually facilitates more accurate measures of exposure (48). In addition, this study does not report categories of tissue or injury pathology as recommended by others (19). From a practical and a research perspective, it is relevant to obtain as much information as possible about an injury, and this would have qualified our findings further. Also, the study includes participants from a selected group of male elite level football players below the age of 17 years. Injury risk in football may depend on gender, playing level and age-group. Therefore, extending our findings to other groups of players or other high-risk team sports should be done with caution. Finally, specific playing positions (e.g., goal keepers) may be subjected to different injury risk profiles (49). However, this is less well-described in youth elite football players (17) and is subject to future investigations.

In summary, during the investigation period, the main causes of missed team practice and match play in young male elite football players were lower extremity sudden-onset and gradual-onset. Injury incidence per 1,000 h was higher during match play compared to team practice, and the players took part of a significant number of weekly supportive activities. The injury pattern in youth players was comparable to that of adult players, with knee and head injuries displaying the highest burden and resulted in the most days lost per injury, respectively. As such, effective monitoring of health problems and physical exposure may guide medical and sports science practitioneers to optimize training and recovery processes, and to secure player development and long-term academy productivity.

## Practical recommendations

Implementing a continuous monitoring system across age groups and teams will allow for the identification of players at particular risk during transition phases or other periods of increased risk (e.g., after holiday periods, national team camp breaks, or during congested match fixtures). Applying this approach may aid sports science staff members in adapting their training processes to align with the players' capacities at different time points throughout the season.

In this study, a web application was used to collect player data, and a high response rate was achieved. To ensure accurate and timely responses to the injury survey, it is advisable to assign dedicated staff members with the responsibility of guiding the players, as demonstrated in this study. This may increase the validity of the collected data and facilitate subsequent data processing and analysis. Similarly, it is advised to gather sufficient information on injury mechanisms regardless of the type of injury and to include injury burden as a tool for analysis. This will improve the possibility of tailoring individual injury prevention and performance-enhancing training processes. Including options for reporting self-initiated training activities may be beneficial, as not all training forms are included in load management models presently applied in elite football. This inclusion has the potential to enhance the identification of players at risk of sustaining undesirable states of overtraining and thus decrease the risk of gradual-onset injuries.

## 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 humans were approved by Ethic Committee of Southern Denmark. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual (s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

## Author contributions

Conceived and designed the study: TRA, MM Collected the data: TRA Analyzed the data and interpreted the findings: TRA, AD, SM, MM Wrote the paper: TRA, AD Accepted the final version of the manuscript: TRA, AD, SM, MM. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

1. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act*. (2010) 7:40. doi: 10.1186/1479-5868-7-40

2. Belechri M, Petridou E, Kedikoglou S, Trichopoulos D. Sports injuries among children in six European union countries. *Eur J Epidemiol*. (2001) 17(11):1005–12. doi: 10.1023/A:1020078522493

3. Bueno AM, Pilgaard M, Hulme A, Forsberg P, Ramskov D, Damsted C, et al. Injury prevalence across sports: a descriptive analysis on a representative sample of the Danish population. *Inj Epidemiol*. (2018) 5(1):6. doi: 10.1186/s40621-018-0136-0

4. Le Gall F, Carling C, Reilly T, Vandewalle H, Church J, Rochcongar P. Incidence of injuries in elite French youth soccer players: a 10-season study. *Am J Sports Med*. (2006) 34(6):928–38. doi: 10.1177/0363546505283271

5. Pfirrmann D, Herbst M, Ingelfinger P, Simon P, Tug S. Analysis of injury incidences in male professional adult and elite youth soccer players: a systematic review. *J Athl Train*. (2016) 51(5):410–24. doi: 10.4085/1062-6050-51.6.03

6. Dvorak J, Junge A, Derman W, Schwellnus M. Injuries and illnesses of football players during the 2010 FIFA world cup. *Br J Sports Med*. (2011) 45(8):626–30. doi: 10.1136/bjsm.2010.079905

7. Junge A, Lamprecht M, Stamm H, Hasler H, Bizzini M, Tschopp M, et al. Countrywide campaign to prevent soccer injuries in Swiss amateur players. *Am J Sports Med*. (2011) 39(1):57–63. doi: 10.1177/0363546510377424

8. Valderrabano V, Hintermann B, Horisberger M, Fung TS. Ligamentous posttraumatic ankle osteoarthritis. *Am J Sports Med*. (2006) 34(4):612–20. doi: 10.1177/0363546505281813

9. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med*. (1992) 14(2):82–99. doi: 10.2165/00007256-199214020-00002

10. Clarsen B, Rønsen O, Myklebust G, Flørenes TW, Bahr R. The Oslo sports trauma research center questionnaire on health problems: a new approach to prospective monitoring of illness and injury in elite athletes. *Br J Sports Med*. (2014) 48(9):754–60. doi: 10.1136/bjsports-2012-092087

11. Ekegren CL, Gabbe BJ, Finch CF. Sports injury surveillance systems: a review of methods and data quality. *Sports Med*. (2016) 46(1):49–65. doi: 10.1007/s40279-015-0410-z

12. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo sports trauma research centre (OSTRC) overuse injury questionnaire. *Br J Sports Med*. (2013) 47(8):495–502. doi: 10.1136/bjsports-2012-091524

13. Clarsen B, Bahr R, Myklebust G, Andersson SH, Docking SI, Drew M, et al. Improved reporting of overuse injuries and health problems in sport: an update of the Oslo sport trauma research center questionnaires. *Br J Sports Med*. (2020) 54 (7):390–6. doi: 10.1136/bjsports-2019-101337

14. Dalen-Lorentsen T, Bjørneboe J, Clarsen B, Vagle M, Fagerland MW, Andersen TE. Does load management using the acute:chronic workload ratio prevent health problems? A cluster randomised trial of 482 elite youth footballers of both sexes. *Br J Sports Med*. (2021) 55(2):108–14. doi: 10.1136/bjsports-2020-103003

15. Jaber A, Weishorn J, Berrsche G, Ott H, Bangert Y. Injury profile among elite youth male football players in a German academy. *Int J Sports Med*. (2022) 43 (2):138–44. doi: 10.1055/a-1516-4139

16. Mashimo SYN, Hogan T, Waki H, Minakawa Y, Miyazaki S, Koido M. Prevalence and burden of injuries and illnesses in men's university football players: a prospective cohort study in 2020 competitive season. *Int J Sports Med*. (2022) 11(4):9.

17. Mandorino M, Figueiredo AJ, Gjaka M, Tessitore A. Injury incidence and risk factors in youth soccer players: a systematic literature review. Part II: intrinsic and extrinsic risk factors. *Biol Sport*. (2023) 40(1):27–49. doi: 10.5114/biolsport.2023.109962

18. Wik EH, Lolli L, Chamari K, Materne O, Di Salvo V, Gregson W, et al. Injury patterns differ with age in male youth football: a four-season prospective study of 1111 time-loss injuries in an elite national academy. *Br J Sports Med*. (2021) 55 (14):794–800. doi: 10.1136/bjsports-2020-103430

19. Bahr R, Clarsen B, Derman W, Dvorak J, Emery CA, Finch CF, et al. International olympic committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sports 2020 [including the

STROBE extension for sports injury and illness surveillance (STROBE-SIIS)]. *Orthop J Sports Med*. (2020) 8(2):2325967120902908.

20. Waldén M, Mountjoy M, McCall A, Serner A, Massey A, Tol JL, et al. Football-specific extension of the IOC consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020. *Br J Sports Med*. (2023).

21. Hägglund M, Waldén M, Magnusson H, Kristenson K, Bengtsson H, Ekstrand J. Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA champions league injury study. *Br J Sports Med*. (2013) 47 (12):738–42. doi: 10.1136/bjsports-2013-092215

22. Bjørndal CT, Bache-Mathiesen LK, Gjesdal S, Moseid CH, Myklebust G, Luteberget LS. An examination of training load, match activities, and health problems in Norwegian youth elite handball players over one competitive season. *Front Sports Act Living*. (2021) 3:635103. doi: 10.3389/fspor.2021.635103

23. Robles-Palazón FJ, López-Valenciano A, De Ste Croix M, Oliver JL, García-Gómez A, Sainz de Baranda P, et al. Epidemiology of injuries in male and female youth football players: a systematic review and meta-analysis. *J Sport Health Sci*. (2022) 11(6):681–95. doi: 10.1016/j.jshs.2021.10.002

24. Bult HJ, Barendrecht M, Tak IJR. Injury risk and injury burden are related to age group and peak height velocity among talented male youth soccer players. *Orthop J Sports Med*. (2018) 6(12):2325967118811042.

25. McBurnie AJ, Dos'Santos T, Johnson D, Leng E. Training management of the elite adolescent soccer player throughout maturation. *Sports (Basel)*. (2021) 9(12).

26. Andersen TR, Kästner B, Arvig M, Larsen CH, Madsen EE. Monitoring load, wellness and psychological variables in female and male youth national team football players during international and domestic playing periods. *Front Sports Act Living*. (2023) 5:1197766. doi: 10.3389/fspor.2023.1197766

27. Faude O, Rößler R, Junge A. Football injuries in children and adolescent players: are there clues for prevention? *Sports Med*. (2013) 43(9):819–37. doi: 10.1007/s40279-013-0061-x

28. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football: the UEFA injury study. *Br J Sports Med*. (2011) 45(7):553–8. doi: 10.1136/bjsm.2009.060582

29. Bahr R. No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med*. (2009) 43(13):966–72. doi: 10.1136/bjsm.2009.066936

30. Le Gall F, Carling C, Reilly T. Biological maturity and injury in elite youth football. *Scand J Med Sci Sports*. (2007) 17(5):564–72. doi: 10.1111/j.1600-0838.2006.00594.x

31. Ruf L, Altmann S, Graf F, Romeike C, Wirths C, Wohak O, et al. Injury incidence, severity, and burden in elite youth soccer players—a 3-year prospective study. *J Sci Med Sport*. (2022) 25(9):737–42. doi: 10.1016/j.jsams.2022.06.003

32. Wik EH. Growth, maturation and injuries in high-level youth football (soccer): a mini review. *Front Sports Act Living*. (2022) 4:975900. doi: 10.3389/fspor.2022.975900

33. Varley M, Gregson W, McMillan K, Bonanno D, Stafford K, Modonutti M, et al. Physical and technical performance of elite youth soccer players during international tournaments: influence of playing position and team success and opponent quality. *Sci Med Football*. (2016) 1:12.

34. Bangsbo J, Mohr M, Krustrup P. Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci*. (2006) 24(7):665–74. doi: 10.1080/02640410500482529

35. Price RJ, Hawkins RD, Hulse MA, Hodson A. The football association medical research programme: an audit of injuries in academy youth football. *Br J Sports Med*. (2004) 38(4):466–71. doi: 10.1136/bjsm.2003.005165

36. Bjordal JM, Arnły F, Hannestad B, Strand T. Epidemiology of anterior cruciate ligament injuries in soccer. *Am J Sports Med*. (1997) 25(3):341–5. doi: 10.1177/036354659702500312

37. Chahla J, Sherman B, Cinque M, Miranda A, Garrett WE, Chiampas G, et al. Epidemiological findings of soccer injuries during the 2017 gold cup. *Orthop J Sports Med*. (2018) 6(8):2325967118791754. doi: 10.1177/2325967118791754

38. Steib S, Rahlf AL, Pfeifer K, Zech A. Dose-response relationship of neuromuscular training for injury prevention in youth athletes: a meta-analysis. *Front Physiol*. (2017) 8:920. doi: 10.3389/fphys.2017.00920

39. Fuller C, Drawer S. The application of risk management in sport. *Sports Med*. (2004) 34(6):349–56. doi: 10.2165/00007256-200434060-00001

40. Beaudouin F, Gioftsidou A, Larsen MN, Lemmink K, Drust B, Modena R, et al. The UEFA heading study: heading incidence in children's and youth' football (soccer) in eight European countries. *Scand J Med Sci Sports*. (2020) 30(8):1506–17. doi: 10.1111/sms.13694

41. Mooney J, Self M, ReFaey K, Elsayed G, Chagoya G, Bernstock JD, et al. Concussion in soccer: a comprehensive review of the literature. *Concussion*. (2020) 5(3):Cnc76. doi: 10.2217/cnc-2020-0004

42. Larsson D, Ekstrand J, Karlsson MK. Fracture epidemiology in male elite football players from 2001 to 2013: "how long will this fracture keep me out?". *Br J Sports Med*. (2016) 50(12):759–63. doi: 10.1136/bjsports-2015-095838

43. Andersson JK, Bengtsson H, Waldén M, Karlsson J, Ekstrand J. Hand, wrist, and forearm injuries in male professional soccer players: a prospective cohort study of 558 team-seasons from 2001 to 2002 to 2018-2019. *Orthop J Sports Med*. (2021) 9 (1):2325967120977091. doi: 10.1177/2325967120977091

44. Bahr R, Clarsen B, Ekstrand J. Why we should focus on the burden of injuries and illnesses, not just their incidence. *Br J Sports Med*. (2018) 52(16):1018–21. doi: 10.1136/bjsports-2017-098160

45. Ekstrand J, Gillquist J, Möller M, Oberg B, Liljedahl S-O. Incidence of soccer injuries and their relation to training and team success. *Am J Sports Med*. (1983) 11 (2):63–7. doi: 10.1177/036354658301100203

46. Maffulli N, Longo UG, Gougoulias N, Loppini M, Denaro V. Long-term health outcomes of youth sports injuries. *Br J Sports Med*. (2010) 44(1):21–5. doi: 10.1136/bjsm.2009.069526

47. Waldén M, Ekstrand J, Hägglund M, McCall A, Davison M, Hallén A, et al. Influence of the COVID-19 lockdown and restart on the injury incidence and injury burden in men's professional football leagues in 2020: the UEFA elite club injury study. *Sports Med Open*. (2022) 8(1):67. doi: 10.1186/s40798-022-00457-4

48. Moller M, Attermann J, Myklebust G, Wedderkopp N. Injury risk in Danish youth and senior elite handball using a new SMS text messages approach. *Br J Sports Med*. (2012) 46(7):531–7. doi: 10.1136/bjsports-2012-091022

49. Della Villa F, Mandelbaum BR, Lemak LJ. The effect of playing position on injury risk in male soccer players: systematic review of the literature and risk considerations for each playing position. *Am J Orthop (Belle Mead NJ)*. (2018) 47(10).

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# Differences between 48 and 72-hour intervals on match load and subsequent recovery: a report from the Brazilian under-20 national football team

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**Purpose:** To compare the external and internal load and subsequent recovery of football players after international tournament matches separated by 48 h vs. 72 h. **Methods:** A total of 14 male football players from the Brazilian National Team, competing in the 2019 South American Under-20 Championship, participated in the study. Match load was quantified using GPS variables and perceived exertion ratings (1). Additionally, before and 13–15 h after each match, players answered questions about the number of hours and quality of sleep, recovery status, and muscle soreness (0–10) and provided a blood sample for creatine kinase and reactive C-protein analysis. Values of all variables were compared between matches played with 48-h intervals (matches 1–4) and 72-h intervals (matches 5–8). **Results:** No significant differences in performance or perceptual parameters were observed between matches ($p = 0.136–0.953$). However, CK was higher in matches 1–4 compared to matches 5 and 6; and $\Delta$PCR was higher in matches 2 and 3 compared to matches 5 and 6, and in match 4 compared to matches 5 and 8. **Conclusions:** After matches with a 48-h rest interval, players showed increased markers of inflammation and muscle damage compared to matches with a 72-h rest interval.

KEYWORDS

congested schedule, match interval, youth, soccer, national team, recovery, fatigue

## Introduction

Congested schedule in football is defined as a sequence of two or more matches separated by ≤96 h (1), which is frequently experienced by elite players involved in concomitant tournaments for their clubs and respective national teams throughout a season. Such long and congested calendars also add pressure on health and performance staff, players are exposed to higher levels of fatigue and lower levels of recovery, possibly affecting players' readiness to perform and risk of injury (2, 3). In fact, studies of post-match recovery time

indicate that players' strength, sprint, and countermovement jump performance are reduced, as well creatine kinase (CK), reactive C-protein (PCR) concentrations and perceptions of fatigue can be increased after 72 h or more (1, 4, 5). Despite such evidence, international tournament regulations allow consecutive matches to be played at least 48 h apart (6). The South American Under-20 (U20) Championship is an example: it is organized in a two-phase, score-based format, with the interval between matches varying between 48 and 72 h, requiring teams to show a solid campaign throughout.

Previous studies have investigated the effect of consecutive matches with short intervals on the physical demands (7–10) in elite football. Muñoz-Castellanos (2022) observed reduced high-intensity decelerations in the third match compared to the first match played within a 7-day period in elite under-14 (U14), U16, and U19 football players, as well as position-specific differences in distance covered at various speeds between matches. In contrast, other studies did not find differences in external load variables in consecutive matches played with a 72-h interval (7, 8). Given the different findings reported in the literature, Julian et al. (1) concluded that both total and high-intensity distances are not impaired, although players may adapt their activity profiles when playing matches with ≤72-h intervals.

The physical demands of football are influenced by the technical, tactical, and contextual elements of the game (11). In this context, players may self-regulate their activity profile, supported by psycho-physiological aspects, to cope with the overall demands of the match. For example, Mohr et al. (12) compared three matches played in one week (interval between matches 1–2: 72 h, interval between matches 2–3: 96 h). The authors found increased muscle damage (CK), inflammatory markers (PCR), and perception of muscle soreness 48 h after match 2 compared to match 1, but no differences between matches 3 and 1, despite the fact that the players had covered lower distances at high speed in match 2 compared to matches 1 and 3. This suggests that an accumulated fatigue effect (13) may influence recovery if a match is preceded by 72 h compared to 96 h. In addition, fatigue may impair players' response to dynamic disturbances, and mental fatigue may impair technical and tactical performance (14), potentially affecting overall performance and the risk of injury. In fact, Bengtsson (3) demonstrated an approximately 30% increase in football hamstring injuries in the Europa League with matches separated by less than 4 days compared to games separated by more than 6 days. Although the risk of injury is lower in youth groups compared to professional groups, the risk increases with age (15), placing U-20 players at a potentially high risk of injury when submitted to a congested schedule.

As shown, the literature provides evidence for poorer recovery after matches separated by 72 h compared to ≥96 h, but the possible consequences of playing consecutive games separated by the shortest match interval allowed in international tournaments (48 h) have not yet been investigated. Therefore, this study aimed to analyze the differences between two short match intervals (48 h vs. 72 h) in external and internal match load and subsequent recovery markers in an international tournament. To do so, we used data from the 2019 U20 South American Tournament, in which the Brazilian team played all four matches of the first phase with a 48-h interval and all five matches in the second phase with a 72-h interval.

# Materials and methods

## Subjects

The study comprised data from 14 male football players who competed in the 2019 South American U20 Championship for the Brazilian National Team (178.7 ± 5.9 cm, 74.0 ± 7.7 kg, sum of 7 skinfolds: 46.1 ± 5.1 mm), finishing in the fifth place. Inclusion criteria were: (1) being an outfield player; and (2) having played at least one entire match during each phase of the competition. Of the 22 players on the team, three goalkeepers, one outfield player who did not play a full match, and three players who did not play at least one full game in both the first and second phases of the competition were excluded from the analysis. The study was conducted in accordance with the Declaration of Helsinki, 1995, and was approved by the State Ethics Committee of the Federal University of Minas Gerais (47083721.0.0000.5149).

## Study design

This is an observational case study. Data were collected by the team's staff during the championship and used for scientific purposes with the consent of the Brazilian Football Confederation.

## Training and tournament

All players selected for the team participated in a training camp at the Brazilian National Training Centre in Teresópolis. The first phase of the camp consisted of 4 days of initial assessments and familiarization with the training procedures. On the first day, the players underwent medical and anthropometric assessments, followed by 3 days of light-to-moderate- intensity training sessions in the afternoons. At lunchtime before the training session of the third day, blood samples were collected to determine CK and PCR concentrations, which were later used as reference values. After a 5-day Christmas break, the team trained for 17 days in Brazil before traveling to the tournament's host city.

The 2019 South American U20 Championship took place between 14 January and 10 February 2019 (Rancagua, Chile), in two phases. The first phase consisted of four matches separated by 48 h. Following the classification for the second phase, after a 3-day break, the team played five games with a 72-h rest interval (Table 1). Dates, times, opponents, and final results are presented in Table 2.

## Pre-match assessments

On the morning of each match, players responded online to a custom-designed questionnaire: number of hours and quality of sleep (rated from 1: Very, very good to 7: Very, very bad), state

TABLE 1 Team schedule during the training period and the tournament.

| | Days of the month and activity performed | | | | | | |
|---|---|---|---|---|---|---|---|
| Training (Brazil) | Dec—17 | 18 | 19 | 20 | 21 | 22–25 | |
| | Testing | Training | Training | Blood sample<br>Training | Friendly Match | Off | |
| | Dec 26 to Jan 11 | | | | | Jan—12 | |
| | Training camp | | | | | Trip to Chile | |
| Tournament (Chile) | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | Training | Training | Training | Training | Training | Match 1<br>18:10–0 × 0<br>Colombia | Recovery |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | Match 2<br>20:30–2 × 1<br>Venezuela | Recovery | Match 3<br>20:30–0 × 1<br>Chile | Recovery | Match 4<br>20:30–1 × 0<br>Bolivia | Recovery | Training |
| | 28 | 29 | 30 | 31 | 1 | 2 | 3 |
| | Training | Match 5<br>18:30–0 × 0<br>Colombia | Recovery | Training | Match 6<br>22:10–0 × 2<br>Venezuela | Recovery | Training |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Match 7<br>18:30–2 × 3<br>Uruguay | Recovery | Training | Match 8<br>20:50–0 × 0<br>Ecuador | Recovery | Training | Match 9<br>22:10–1 × 0<br>Argentina |

of recovery (from 0: rested to 10: completely recovered) (16), and muscle soreness (rated from 0: no soreness to 10: extremely sore). The same questionnaire was used in all training camps with the youth national teams; thus, the players were familiarized with it for a minimum of 6 months.

## Match load

Match load parameters were obtained using global positioning system (GPS) units operating at 10 Hz (Statsport®, Newry, Ireland) with an attached accelerometer. The units were switched on 60 min prior to the start of the match and were fitted to the players' upper backs using adjustable neoprene harnesses. Activity profiles were quantified by total distance, distance covered in high-speed running (>20 km.h$^{-1}$) and sprinting (>24 km.h$^{-1}$), the total number of high-intensity accelerations (n. accel) (>3 m.s$^{-2}$), and decelerations (n. decel) (< −3 m.s$^{-2}$). Approximately 30 min after the match, players rated their perceived exertion (RPE; 0: very light to 10: maximum) (16).

TABLE 2 Tournament dates, times, opponents, and results.

| Phase | Date | Time | Opponent | Score[a] |
|---|---|---|---|---|
| 1st | 19/01/2019 | 18:10 | Colombia | 0 × 0 |
| | 21/01/2019 | 20:30 | Venezuela | 2 × 1 |
| | 23/01/2019 | 20:30 | Chile | 0 × 1 |
| | 25/01/2019 | 20:30 | Bolivia | 1 × 0 |
| 2nd | 29/01/2019 | 18:30 | Colombia | 0 × 0 |
| | 01/02/209 | 22:10 | Venezuela | 0 × 2 |
| | 4/02/2019 | 18:30 | Uruguay | 2 × 3 |
| | 7/02/2019 | 20:50 | Ecuador | 0 × 0 |
| | 10/02/2019 | 22:10 | Argentina | 1 × 0 |

[a]Score is presented as Brazil x opponent.

## Post-match assessments

On the day following each match (approximately after 13–15 h), a fingertip blood sample was collected for analysis of PCR (Ichroma, Boditech®, Korea) and CK concentrations (Reflotron, Roche®, Switzerland). Additionally, players reported their level of muscle soreness using a visual analog scale. *Δ*PCR and *Δ*CK were calculated as the post-match PCR and CK values minus their respective reference values.

## Statistical Analyses

The data distribution was verified (Shapiro–Wilk). Most variables were non-normally distributed (pre- and post-match recovery, pre- and post-match soreness, RPE, and *Δ*PCR), and comparisons between matches were made using Kruskal–Wallis followed by Dunn's *post-hoc*. Normally distributed variables (total distance, n. accel, n. decel, dist. > 20 km.h$^{-1}$ and dist. sprint) were analyzed using a one-way ANOVA followed by Tukey's *post-hoc* when applicable. All data are shown as median ± interquartile interval for clarity of presentation.

To acknowledge between-player variability, we also performed a repeated-measures analysis with data from those players who played for 90-min in consecutive matches during both phases of

the tournament. Due to player rotation and substitution, only data from 5 players who participated in two consecutive matches in each phase were used. One of the players did not wear the GPS unit in game 2, and thus GPS-related variables were compared with an $n = 4$. Matches 1 and 2 (48-h interval) and matches 5 and 6 from the second phase (72-h interval) were compared using either ANOVA (n. accel, n. decel, dist. > 20 km.h$^{-1}$, and dist. sprint) followed by Tukey's *post hoc* when applicable or Friedman (total distance, pre- and post-match recovery, pre and post-match soreness, RPE, ΔCK, and ΔPCR), followed by Wilcoxon *post-hoc* when applicable.

Effect sizes were calculated as the partial eta squared ($\eta^2$) for Kruskal–Wallis and ANOVA, and Kendall's W for Friedman tests.

## Results

There were no differences in pre-match assessments or match demands across the tournament ($p = 0.092$–$0.953$, $\eta^2 = 0.119$–$0.227$) (Figure 1).

In the post-match assessments, muscle soreness was also similar across matches. However, the Kruskal–Wallis test was significant for ΔCK ($p = 0.005$, $\eta^2 = 0.238$) and ΔPCR ($p = 0.001$; $\eta^2 = 0.330$). *Post hoc* analysis showed that ΔCK was higher after matches 1 to 4 compared to matches 5 and 6 ($p < 0.001$–$0.039$). ΔPCR was higher in matches 2 and 3 compared to all matches on the second phase, i.e., matches 5–8 ($p = 0.001$–$0.045$), and ΔPCR after match 4 was higher than that in matches 6 ($p = 0.030$) and 8 ($p = 0.021$).

When only data from the same players were included in the analysis, no differences in pre-match assessments were observed between 48-h or 72-h interval situations: soreness ($p = 0.112$; W = 0.400), recovery ($p = 0.106$; $W = 0.407$).

Regarding match load, no differences were observed in distance sprinting ($p = 0.155$, $\eta^2$ 0.455), distance traveled above 20 km/h ($p = 0.590$, $\eta^2 = 0.566$), or RPE ($p = 0.063$, $W = 0.487$) among matches.

Total distance ($W = 0.686$) and number of decelerations ($\eta^2 = 0.835$) were lower in match 5 compared to matches 1 ($p = 0.020$ and $p = 0.004$, respectively) and 2 ($p = 0.020$ and $p = 0.003$, respectively). The number of accelerations ($\eta^2 = 0.714$) was lower in match 5 compared to match 2 ($p = 0.019$) and higher in match 6 compared to match 5 ($p = 0.016$).

No differences were observed in post-game soreness ($p = 0.096$, $W = 0.423$). ΔCK ($W = 0.592$) and ΔPCR ($W = 0.587$) values were higher after match 2 compared to matches 5 ($p = 0.043$) and 6 ($p = 0.043$).

## Discussion

This study showed that players experienced higher post-match markers of inflammation and muscle damage following a 48-h interval between matches compared to 72-h intervals in an international tournament, even with similar match loads.

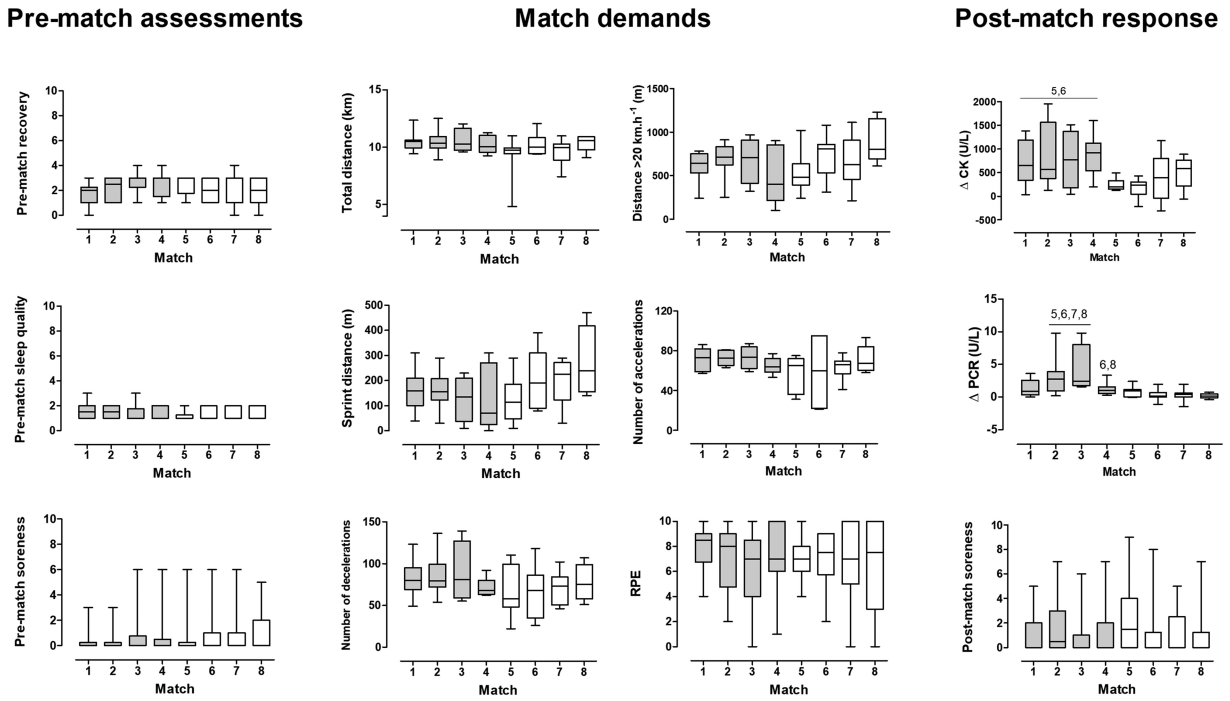


FIGURE 1
Boxplot of pre-match assessments, match demands, and post-match responses for each match during the 2019 South American U20 championship. Bars in gray represent matches played during the first phase, and bars in white represent matches played during the second phase. [5]Different from match 5, [6]Different from match 6, [7]Different from match 7, [8]Different from match 8.

The similar results in physical performance between matches with 48-h and 72-h intervals (i.e., matches 2, 3, and 4 vs. matches 6, 7, and 8) are in line with a previous study that investigated the differences between 48-h and 72-h intervals in treadmill-simulated conditions in semi-professional football players (17). Other studies on congested schedules have also found similar results, although the between-match interval investigated was longer (72–96 h vs. >96 h) (4, 18). The fact that physical performance during football matches results from a combination of players' physical fitness and technical-tactical demands (4), rather than demands for maximal physical performance, may explain this finding.

The physiological stress was higher in a subsequent match when the rest interval was 48 h (match 2) compared to 72 h (match 6). This was assessed by ΔCK considering all field players (Figure 1) and by both ΔCK and ΔPCR considering only repeated measures (players who participated in both matches—Figure 2). Interestingly, these were the only markers that showed the same pattern across players (worse response in match 6 compared to match 2). This was expected based on previous studies showing increased PCR and CK up to 72 h post-match (4). In addition, match load variables that have been demonstrably associated with muscle damage markers, i.e., distance in high-speed running and sprinting (19), were similar between matches separated by 48 h or 72 h (Figure 2). The differences observed in total distance, n. of accelerations, and n. of decelerations may also have influenced the higher CK and PCR concentrations in the first phase compared to the second, although this effect has been shown to be smaller (19, 20). Thus, the 48-h between-match interval appears to lead to a cumulative fatigue effect (21), which has been associated with a higher risk of injury in the long term (18).

Interestingly, the perception of recovery and soreness before the games did not differ between the two intervals, and individual tendencies varied from improved, similar, or worse responses after the 48-h interval compared to the 72-h interval. As no concomitant physiological assessments were available, discussions may be limited. Of note, players were familiarized with the scale and possible interpretations and follow-up decisions by the coaching staff based on their responses (e.g., low recovery scores may indicate poor readiness to play, which may lead to reduced training/game time), whereas playing for the national team is perceived as important for U20 players willing to scale to the professional level. Therefore, we speculate that players may avoid reporting low recovery states immediately before the game. Similar influences have been reported for psychometric measures that rely on player honesty for accuracy (22). Additionally, recovery is a multifactorial phenomenon that may be influenced by factors not assessed here, such as aerobic power, strength, sleep, nutrition, and mood (21, 23).

This study provides valuable insights into its ecological validity in a high-performance setting. However, this is a case study with a limited capacity for extrapolation, and its ecological nature also comes with limitations. First, the fact that players in a national team come from different clubs, being exposed to different training and possibly different stages of the season, brings great variability to their initial assessments. To partially overcome this, the baseline CK concentration was considered to be measured

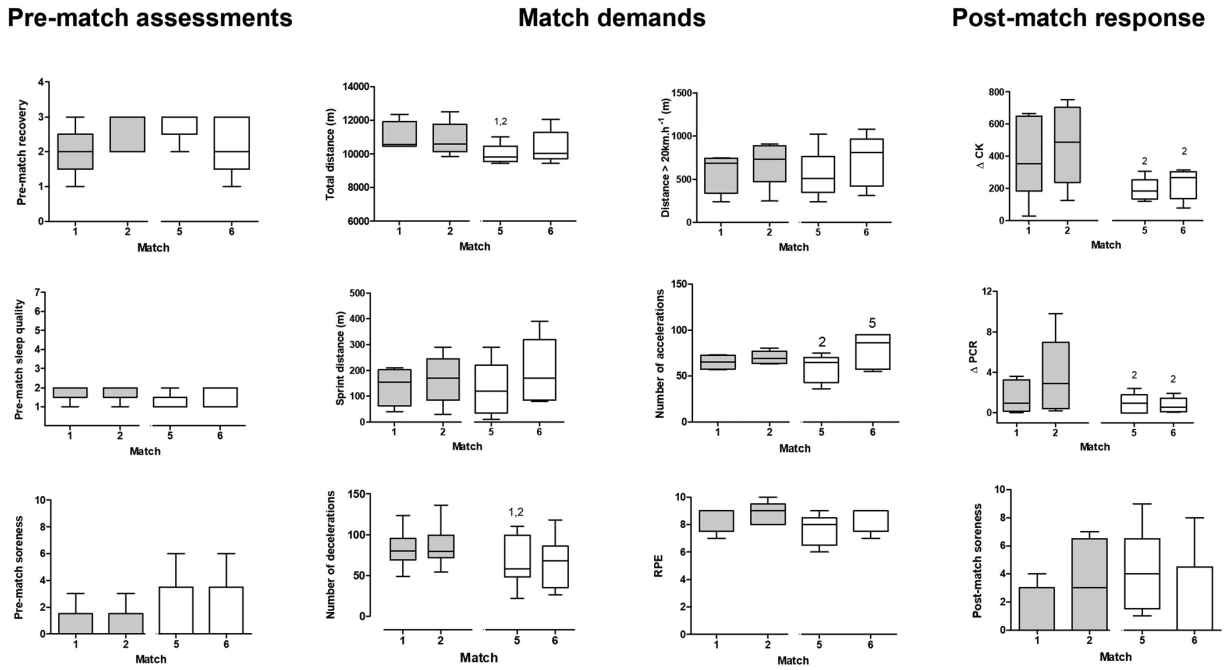


FIGURE 2
Boxplot of results of pre-, during, and post-game assessments in matches 2 (48 h after match 1) and 6 (72 h after match 5), for players who participated in 90 min of matches 1, 2, 5, and 6. [1]Different from match 1, [2]Different from match 2, [5]Different from match 5.

after 4 days of standardized training and routine (time of meals and rest periods). The authors acknowledge the high variability of CK concentration but are supported by studies that also acknowledge its relevance in player fatigue and recovery monitoring programs (13, 20). In addition, the logistics and pressure of an international championship limit the opportunities for data acquisition. Our recovery measures were performed on the day after the match to provide evidence for training load management in the following days, given the short rest intervals between matches. Finally, given the differences in which players were involved in each match, we had limited opportunity for repeated-measures analysis. It is possible that different outcomes would result from a more controlled context, and thus we suggest that further studies be performed to investigate the effects of 48-h match-intervals vs. 72-h intervals or longer.

In conclusion, matches played after a 48-h rest interval were followed by increased markers of inflammation and muscle damage compared to games played after a 72-h interval, with no effect on game demands.

## 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 humans were approved by Universidade Federal de Minas Gerais. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because Data used for the study is part of the national team database of daily activities undergone by players within the national team context.

## Author contributions

CFW – First authorship - study conception, data analysis and manuscript development. CCC – contribution to data analysis and manuscript development. FRD – contribution to data analysis and manuscript development. LRD – contribution to data analysis and manuscript development. HOC – contribution to data analysis and manuscript development. TK – data collection and contribution to manuscript development. GPR – study conception, data analysis and manuscript development. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

GPR is a full-time employee of the Brazilian Football Confederation.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

1. Julian R, Page RM, Harper LD. The effect of fixture congestion on performance during professional male soccer match-play: a systematic critical review with meta-analysis. *Sports Med.* (2021) 51(2):255–73. doi: 10.1007/s40279-020-01359-9

2. McCall A, Davison M, Andersen TE, Beasley I, Bizzini M, Dupont G, et al. Injury prevention strategies at the FIFA 2014 world cup: perceptions and practices of the physicians from the 32 participating national teams. *Br J Sports Med.* (2015) 49 (9):603–8. doi: 10.1136/bjsports-2015-094747

3. Bengtsson H, Ekstrand J, Walden M, Hagglund M. Muscle injury rate in professional football is higher in matches played within 5 days since the previous match: a 14-year prospective study with more than 130 000 match observations. *Br J Sports Med.* (2018) 52(17):1116–22. doi: 10.1136/bjsports-2016-097399

4. Silva JR, Rumpf MC, Hertzog M, Castagna C, Farooq A, Girard O, et al. Acute and residual soccer match-related fatigue: a systematic review and meta-analysis. *Sports Med.* (2018) 48(3):539–83. doi: 10.1007/s40279-017-0798-8

5. Nedelec M, McCall A, Carling C, Legall F, Berthoin S, Dupont G. Recovery in soccer: part I—post-match fatigue and time course of recovery. *Sports Med.* (2012) 42(12):997–1015. doi: 10.2165/11635270-000000000-00000

6. FIFA FIdFA. REGULATIONS FIFA U-20 World Cup Poland 2019 2019

7. Folgado H, Duarte R, Marques P, Sampaio J. The effects of congested fixtures period on tactical and physical performance in elite football. *J Sports Sci.* (2015) 33 (12):1238–47. doi: 10.1080/02640414.2015.1022576

8. Carling C, Dupont G. Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? *J Sports Sci.* (2011) 29(1):63–71. doi: 10.1080/02640414.2010.521945

9. Munoz-Castellanos B, Rabano-Munoz A, Requena B, Suarez-Arrones L, Asian-Clemente JA. Congested period in professional youth soccer players showed a different high decelerations profile in the group performance and a specific positional behaviour. *J Funct Morphol Kinesiol.* (2022) 7(4):108. doi: 10.3390/jfmk7040108

10. Odetoyinbo K, Wooster B, Lane A. *The Effect of a Succession of Matches on the Activity Profiles of Professional Soccer Players.* Reilly FK Thomas, editor. London: Routledge (2008).

11. Bradley PS, Ade JD. Are current physical match performance metrics in elite soccer fit for purpose or is the adoption of an integrated approach needed? *Int J Sports Physiol Perform.* (2018) 13(5):656–64. doi: 10.1123/ijspp.2017-0433

12. Mohr M, Draganidis D, Chatzinikolaou A, Barbero-Alvarez JC, Castagna C, Douroudos I, et al. Muscle damage, inflammatory, immune and performance

responses to three football games in 1 week in competitive male players. *Eur J Appl Physiol*. (2016) 116(1):179–93. doi: 10.1007/s00421-015-3245-2

13. Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med*. (2014) 44 Suppl 2(Suppl 2):S139–47. doi: 10.1007/s40279-014-0253-z

14. Smith MR, Coutts AJ, Merlini M, Deprez D, Lenoir M, Marcora SM. Mental fatigue impairs soccer-specific physical and technical performance. *Med Sci Sports Exerc*. (2016) 48(2):267–76. doi: 10.1249/MSS.0000000000000762

15. Cross R, Siegler J, Marshall P, Lovell R. Scheduling of training and recovery during the in-season weekly micro-cycle: insights from team sport practitioners. *Eur J Sport Sci*. (2019) 19(10):1287–96. doi: 10.1080/17461391.2019.1595740

16. Morandi RF, Pimenta EM, Andrade AGP, Serpa TKF, Penna EM, Costa CO, et al. Preliminary validation of mirrored scales for monitoring professional soccer training sessions. *J Hum Kinet*. (2020) 72:265–78. doi: 10.2478/hukin-2019-0112

17. Page RM, Marrin K, Brogden CM, Greig M. The biomechanical and physiological response to repeated soccer-specific simulations interspersed by 48 or 72 h recovery. *Phys Ther Sport*. (2016) 22:81–7. doi: 10.1016/j.ptsp.2016.06.011

18. Noor D, McCall A, Jones M, Duncan C, Ehrmann F, Meyer T, et al. Perceived load, fatigue and recovery responses during congested and non-congested micro-cycles in international football tournaments. *J Sci Med Sport*. (2021) 24 (12):1278–83. doi: 10.1016/j.jsams.2021.07.001

19. Wiig H, Raastad T, Luteberget LS, Ims I, Spencer M. External load variables affect recovery markers up to 72 h after semiprofessional football matches. *Front Physiol*. (2019) 10:689. doi: 10.3389/fphys.2019.00689

20. Beattie CE, Fahey JT, Pullinger SA, Edwards BJ, Robertson CM. The sensitivity of countermovement jump, creatine kinase and urine osmolality to 90-min of competitive match-play in elite English championship football players 48-h post-match. *Sci Med Footb*. (2021) 5(2):165–73. doi: 10.1080/24733938.2020.1828614

21. Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med*. (2014) 44(Suppl 2):S139–47. doi: 10.1007/s40279-014-0253-z

22. McCall A, Wolfberg A, Ivarsson A, Dupont G, Larocque A, Bilsborough J. A qualitative study of 11 world-class team-sport Athletes' experiences answering subjective questionnaires: a key ingredient for 'visible" health and performance monitoring? *Sports Med*. (2023) 53(5):1085–100. doi: 10.1007/s40279-023-01814-3

23. Wilke CF, Fernandes FAP, Martins FVC, Lacerda AM, Nakamura FY, Wanner SP, et al. Faster and slower post-training recovery in futsal: multifactorial classification of recovery profiles. *Int J Sports Physiol Perform*. (2019) 14(8):1089–95. doi: 10.1123/ijspp.2018-0626

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