MODELING HUMAN POTENTIAL ACROSS THE LIFESPAN

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MODELING HUMAN POTENTIAL ACROSS THE LIFESPAN

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EDITORIAL
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Editorial: Modeling Human Potential Across the Lifespan

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Keywords: sport, expertise, creativity, successful aging, age trends

Editorial on the Research Topic

Modeling Human Potential Across the Lifespan

Ebbinghaus (1908) wrote that although "psychology has a long past, yet it's real history is short" (p. 3). The same applies to a scientific understanding of human potential. Simonton (2001) noted a debt owed to nineteenth century polymaths Adolphe Quételet and Francis Galton.

Quetelet (1968) was the first to report quantitative measures of creativity and to discuss bell-shaped distributions of human characteristics. Galton (1869), recognized the significance of the right-side extreme of the normal curve. His research on familial relationships among such high functioning individuals brought the nature vs. nurture controversy into the realm of scientific study.

Models that influenced scientific understandings of lifespan human potential during the past half-century include the sustained deliberate practice model (Ericsson et al., 1993), the successful aging model (Rowe and Kahn, 1987), Simonton's (1990) model of creativity, and statistical models related to adulthood and aging (Schaie and Hertzog, 1985). Articles in this Research Topic aim to advance such modeling primarily with respect to sport.

THE SUSTAINED DELIBERATE PRACTICE MODEL OF EXPERTISE

This model suggests that the primary requirement for the development of expertise is sustained deliberate practice over a prolonged time period. Studies reported here discuss advances in such modeling.

Kennedy and Fairbrother examined the relevance of this model to the infrequently studied field of disability sport. A sample of accomplished quad rugby players provided retrospective accounts of time spent in deliberate practice, competitive play, and daily life activities for 2-year intervals over their careers. The findings supported the model, with times spent practicing similar to that reported for other types of expertise. An unexpected finding was affective neutrality when engaging in deliberate practice. The reason for this finding is unclear.

Baker et al. proposed a distinction between *expert* and *eminent* athletes. They discuss four indicators of eminence able identify elite minorities in various sports. These indicators also show convergent validity. Their discussion focuses on the following issues: limitations of small sample sizes for eminent athletes; whether the latter are outliers or possess special characteristics; practical implications for programming meant to identify winners rather than able competitors.

McCue et al. studied life history and practice history profiles that previously supported the sustained deliberate practice model. They report 17 distinct pathways toward entry into the Major League Baseball (MLB). They divided these pathways into three categories depending on the institution that immediately preceded MLB selection. Given the diversity among pathways, the authors suggest MLB selection might profitably take account of data from high school and post-secondary institutions to supplement draft selection data.

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Buszard et al. reviewed issues related to the relatively neglected topic of scaling in junior sport. For example, the use of playing fields and equipment designed for adults may be reasons for high drop-out and slower development of expertise during pre-adolescence. The authors propose that age-appropriate scaling in junior sport can provide administrators, scientists, and researchers with opportunities to enhance enjoyment and foster expertise regardless of initial ability level.

THE SUCCESSFUL AGING MODEL

This model distinguished between effects due to aging (*Successful Aging*), disuse (*Usual Aging*), and disease (*Secondary Aging*). Subsequent adaptations focused on engagement and attitudes as prerequisites for successful aging.

Carr and Weir used a mixed-methods design to evaluate "how" and "why" engagement profiles change in later life. The quantitative "how" findings included a decrease in productive and active leisure pursuits, with stability in social and passive leisure activities. The qualitative "why" findings provide five categories of reasons for change: health and physiological limitations; death of someone close or important; perceived change in personal freedom; altered level or direction of desires; and external changes.

Although sport has positive implications for successful aging, Littlejohn and Young point out that "Little is known about whether messaging interventions can motivate sport activity" (p. 1). They compared effects of different types of messaging on beliefs about outcomes associated with sports participation. The messages to different groups of middle-aged participants were about (1) the benefits of sport or (2) the preceding plus information about barriers to participation. A control group received no such messaging. They found no differences in outcomes between the messaging groups, although their combination showed some difference from the control group. The authors discuss possible reasons for the low effects of messaging.

Horton et al. interviewed experienced, male Master athletes, experienced to determine attitudes about "sport as a social comparison" and "downward comparison" with non-athletes. Findings for the former indicated that competitive provided them with enhanced motivation to train and prepare. Findings for the latter fell into two categories of "resisting loss" and "assigning blame" (i.e., they believed that poor health related to poor lifestyle rather than extrinsic factors). The authors conclude that social comparison had positive implications for personal well-being but negatively stereotyped non-athletic people.

MODELS OF CREATIVITY

Traditional psychological perspectives on creativity in sport were disparaging about its significance. Simonton (2001) wrote that: "… it is rare for creativity to carry the primary weight in attaining eminence as an athlete or coach in sports" (p. 183). Ericsson et al. (2007) considered that: "Most real-world forms of creative achievement have not yet been successfully measured by objective methods (p.39). However, Vaughan et al. confront such perspectives in this Research Topic. Their article proposed that "creative moments, skill and more generally talent in sport, are not traits possessed by individuals alone but … properties of the athlete-environment system shaped by changing constraints." They advocate a trans-disciplinary perspective that removes disciplinary boundaries" and thereby provides holistic models. A proviso is reciprocity in communicative influence among academics, practitioners and athletes. This paradigm brings forth new challenges and opportunities, particularly with regard to practical applications.

STATISTICAL MODELS OF AGE TRENDS IN MASTERS SPORT

Nikolaidis et al. break new ground in modeling the relationship between age and performance in their study of two distances in the Duathlon World Championships. They analyzed the percentage of race time spent in cycling against with gender, age, and performance quartile groups The findings indicate (1) slower race times with a greater proportion expended on cycling by women than men; (2) proportionately more time for cycling by younger and faster quartile groups; (3) interactions between age and performance quartile groups only in men at the shorter distance. The findings are consistent with other research that showed low age loss in cycling compared to running.

Stones analyzed archival data on the world's best 100 performance times within age group by gender categories for Masters marathon running. One purpose was to compare goodness of fit between traditional forms of analysis with mixed modeling that took account of repeated measures (i.e., age changes), date of performance (i.e., historical trend), and different cohort expressions (i.e., "birth cohort" or "entry cohort," where the latter represents age at entry into the database). The findings indicated that main effect terms in the model included gender, age changes, and entry cohort differences. The second purpose was to determine whether age deterioration differed with performance level. With performances within each age group by gender category divided into quartiles, the findings indicated greater age losses at slower performance levels for both age changes and entry cohort differences.

The articles included in this Research Topic highlight the diversity of topics currently being explored in this field and the value of this research for extending our understanding of human potential across the lifespan.

AUTHOR CONTRIBUTIONS

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

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ORIGINAL RESEARCH
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The Combined Effect of Aging and Performance Level on Pacing in Duathlon – the "ITU Powerman Long Distance Duathlon World Championships"

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The role of age and performance level has been investigated in runners such as marathoners, but not in multi-sports athletes such as duathletes (running, cycling, and running). Thus, the aim of the present study was to examine the combined effects of aging and performance level on pacing of duathletes competing in two different race distances. Pacing (defined as the relative contribution of cycling time, %, to the overall race time) was analyzed for 6,671 duathletes competing from 2003 to 2017 in the short distance race (10 km first run, 50 km cycling and 5 km second run) or long distance race (10 km first run, 150 km cycling and 30 km second run) of "Powerman Zofingen," the "ITU Powerman Long Distance Duathlon World Championships." Men were faster, older, and spent less time (%) in cycling than women in both distances races ($p < 0.001$). Younger age groups spent more time (%) in cycling than their older counterparts in women (both short and long distance, $p = 0.036$, $\eta_p^2 = 0.031$, $p = 0.025$, $\eta_p^2 = 0.044$, respectively) and men (long distance race, $p < 0.001$, $\eta_p^2 = 0.016$). Fast performance groups spent more time (%) in cycling than their slower counterparts in short (women, $p < 0.001$, $\eta_p^2 = 0.057$; men, $p < 0.001$, $\eta_p^2 = 0.035$) and long distance (women, $p < 0.001$, $\eta_p^2 = 0.070$; men, $p < 0.001$, $\eta_p^2 = 0.052$). A small age group × performance group interaction on cycling time (%) was observed in the men's short distance ($p = 0.001$, $\eta_p^2 = 0.020$) – but not in the long distance or in women – with smaller differences between performance groups in the older than in the younger age groups. Women, young and fast duathletes were relatively slower in cycling than men, old and slow duathletes; that was, old duathletes were relatively faster in cycling than in running. Moreover, there was indication that the difference in pacing among performance groups might be attenuated with aging. Since fast duathletes were relatively faster in running than in cycling, slow duathletes should be encouraged to cycle slower and run faster.

Keywords: age group, cycling, endurance, master athletes, running, ultra-endurance

INTRODUCTION

Pacing in endurance performance describes how an athlete invests energy during performance and the pacing strategy during a race can considerably influence the outcome of the race (Nikolaidis and Knechtle, 2017b). To date, six different pacing strategies have been identified such as negative, all-out, positive, even, parabolic-shaped and variable pacing strategies (Abbiss and Laursen, 2008). Pacing during endurance performance has been mainly investigated for runners (Diaz et al., 2018; Nikolaidis and Knechtle, 2018b), swimmers (Nikolaidis and Knechtle, 2017c; Rodriguez and Veiga, 2018), cyclists (Bossi et al., 2018; Granier et al., 2018) and multi-sports athletes such as triathletes (Angehrn et al., 2016; Knechtle and Nikolaidis, 2016). Regarding triathlon (i.e., swimming, cycling, running), pacing has been investigated for different distances such as sprint distance triathlon (Taylor and Smith, 2014; Wu et al., 2015, 2016), Olympic distance triathlon (Vleck et al., 2008), Half-Ironman triathlon (Wu et al., 2015), Ironman triathlon (Johnson et al., 2015; Angehrn et al., 2016), and longer triathlon distances (Herbst et al., 2011; Knechtle and Nikolaidis, 2016). The abovementioned studies focused on the variation of pacing by aspects such as sex, age and performance level and provided practical information for coaches in these sports in order to develop optimal pacing strategies for their athletes.

Apart from triathlon as a multi-sports discipline also duathlon (i.e., running, cycling, and running) exists. However, we have no knowledge how duathletes pace during races of different distances. Recent studies showed the importance of age in pacing. Indeed, studies investigating marathoners found that fast master runners (i.e., older than 35 years) pace differently than slow master runners (Nikolaidis and Knechtle, 2017a,b). Moreover, older runners with a similar race time pace differently than younger runners with smaller changes during the race (Nikolaidis and Knechtle, 2017b).

Duathlon is a multi-sports discipline with a first running leg, then a cycling leg, followed by a second running leg. This change in disciplines can dramatically change pace strategy to achieve the best performance or finish the race at all (Knechtle et al., 2015; Nikolaidis and Knechtle, 2017b). However, there is no evidence regarding pacing strategies in duathlon and about the possible effect of age on it. In addition, the existed knowledge about the role of sex, age and performance level on pacing in triathlon (Knechtle et al., 2019) could not be "transferred" to duathlon considering that these multi-sports differed for their disciplines. On the other hand, information on the role of these aspects on pacing in duathlon would be of practical interest for scientists and practitioners (e.g., coaches and fitness trainers) involving in this sport in order to design optimal pacing strategies considering whether they train women or men, young or older, elite or recreational duathletes. Therefore, the aim of the present study was to investigate the combined effects of aging and performance level on pacing of elite duathletes competing in two different race distances in the "ITU Powerman Long Distance Duathlon World Championships" held at "Powerman Zofingen" in Switzerland. Based upon previous findings for marathoners we hypothesized to find differences in the variation of pacing by performance between younger and older athletes, i.e., smaller differences in pacing among performance groups would be observed in the older age groups.

MATERIALS AND METHODS

Ethics Statement

The Institutional Review Board of Kanton St. Gallen, Switzerland approved all procedures used in the study with a waiver of the requirement for informed consent of the participants given the fact that the study involved the analysis of publicly available data. The study was conducted in accordance with recognized ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

Data

A total of 6,671 duathletes - for whom times for each duathlon's discipline were available – competing from 2003 to 2017 in the "Powerman Zofingen" was considered in the present study. One case with missing age was excluded from further analysis resulting in a final sample of 6,670 duathletes (short distance, women, $n = 556$, men, $n = 2945$; long distance, women, $n = 481$, men, $n = 2688$). All analyses were performed based on data derived from the official race website www.powerman.ch of "Powerman Zofingen." The "Powerman Zofingen" is a duathlon event held in Zofingen (Switzerland) within the "Powerman World Series." In this race, a short and a long distance version are held. A duathlon consists of a running part, a cycling part and then again a running part, which are carried out directly after each other. Since 2002, the long distance race of "Powerman Zofingen" has the sequence of 10 km running, 150 km cycling and 30 km running. At the same time of the long distance race, also a short distance is held covering 10 km running, 50 km cycling, and 5 km running. Before 2003, the race course and the distances of the split disciplines changed several times since the first edition of the race in 1989.

Procedures

Race results were sorted by name, age and sex of the finishers separately for both the short and the long distance race. Athletes were ranked in 5-year age groups from 15–19 years to 70–74 years and their distribution by sex, age and distance can be seen in **Table 1**.

Performance (i.e., relative time) in cycling was expressed as percentage of overall race time using the formula "100 × disciplines" time/total time' and was used as a measure of pacing. The relative time in disciplines were used previously in other multisport to study pacing (Knechtle and Nikolaidis, 2016). We examined the effect of age on pacing (i.e., defined as the relative contribution of cycling time, %, to the overall race time) of duathletes competing in the short distance race (i.e., 10 km first run, 50 km cycling and 5 km second run) or long distance race (i.e., 10 km first run, 150 km cycling, and 30 km second run).

TABLE 1 | Cycling time (%) by sex, distance and age group.

Age group (years)	Short distance				Long distance			
	Women (*n* = 556)		Men (*n* = 2945)		Women (*n* = 481)		Men (*n* = 2688)	
	n	Cycling time (%)	*n*	Cycling time (%)	*n*	Cycling time (%)	*n*	Cycling time (%)
15–19	24	57.85 ± 2.12	107	57.51 ± 1.97	1	60.16	2	57.97 ± 2.23
20–24	49	58.04 ± 2.03	133	57.88 ± 2.50	7	59.63 ± 2.42	70	59.23 ± 2.33
25–29	100	58.41 ± 2.22	275	57.64 ± 2.36	68	60.50 ± 2.14	271	59.77 ± 2.20
30–34	108	57.53 ± 2.21	409	57.73 ± 2.12	103	60.27 ± 2.17	444	59.52 ± 2.17
35–39	99	57.95 ± 2.42	521	57.47 ± 2.01	89	60.19 ± 1.88	511	59.18 ± 2.17
40–44	89	57.48 ± 1.88	556	57.29 ± 2.00	76	59.50 ± 1.91	541	58.82 ± 2.12
45–49	56	57.33 ± 1.73	450	57.09 ± 1.93	76	59.24 ± 2.03	394	58.31 ± 2.12
50–54	25	57.94 ± 1.57	248	57.03 ± 1.82	42	57.82 ± 2.26	235	58.26 ± 2.46
55–59	6	58.63 ± 3.12	145	56.69 ± 1.74	14	56.61 ± 2.78	123	58.16 ± 2.32
60–64			77	55.86 ± 1.51	4	56.51 ± 1.19	59	56.81 ± 2.31
65–69			22	55.66 ± 2.13	1	56.67	32	57.07 ± 2.46
70–74			2	56.22 ± 0.71			6	54.78 ± 2.02

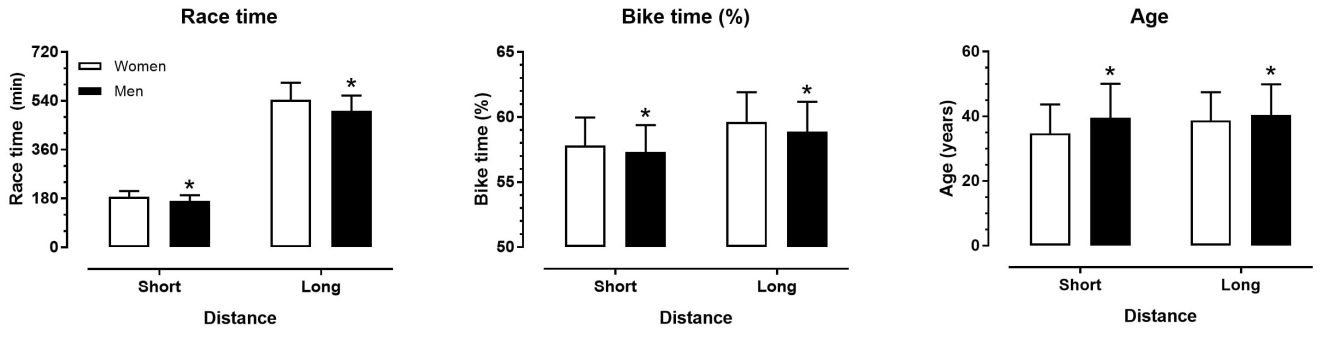

FIGURE 1 | Race time, cycling time (%) and age by sex and distance. *different from women at $p < 0.001$.

Athletes were then also ranked in four quartile groups (Q1, Q2, Q3, and Q4) with Q1 the fastest and Q4 the slowest. In the short distance race, cut-offs for performance quartiles were Q1 ≤ 169.7 min, 169.7 < Q2 ≤ 183.4 min, 183.4 < Q3 ≤ 199.8 min, and Q4 > 199.8 min in women, and Q1 ≤ 157.3 min, 157.3 < Q2 ≤ 168.7 min, 168.7 < Q3 ≤ 183.7 min, and Q4 > 183.7 min in men. In the long distance race, cut-offs for performance quartiles were Q1 ≤ 498.8 min, 498.8 < Q2 ≤ 541.2 min, 541.2 < Q3 ≤ 584.1 min, and Q4 > 584.1 min in women, and Q1 ≤ 461.1 min, 461.1 < Q2 ≤ 499.6 min, 499.6 < Q3 ≤ 542.8 min, and Q4 > 542.8 min in men.

Statistical Analysis

Data are presented as means ± standard deviations. A between-within measures analysis of variance (ANOVA) examined the distance × discipline interaction on relative time. Within each distance, a between-within measures ANOVA examined the sex × discipline and age group × discipline interaction on relative time. The magnitude of these interactions was examined using effect size partial eta square (η_p^2) and was evaluated as following: small ($0.010 < \eta_p^2 \leq 0.059$), moderate ($0.059 < \eta_p^2 \leq 0.138$) and large ($\eta_p^2 > 0.138$) (Cohen, 1988). Statistical analyses were carried out using GraphPad Prism v. 7.0 (GraphPad Software, San Diego, United States) and IBM SPSS v.23.0 (SPSS, Chicago, United States).

RESULTS

Men were faster and older, and spent less time (%) in cycling than women in both distances ($p < 0.001$) (**Figure 1**). A small main effect of age on cycling time (%) was observed in women (both short and long distance, $p = 0.036$, $\eta_p^2 = 0.031$, $p = 0.025$, $\eta_p^2 = 0.044$, respectively) and men's long distance ($p < 0.001$, $\eta_p^2 = 0.016$), whereas no effect was shown in men's short distance ($p = 0.092$, $\eta_p^2 = 0.006$) (**Table 1**). According to this effect, athletes in younger age groups spent more time (%) in cycling than their older counterparts, i.e., young duathletes were relatively slow in cycling.

A small-to-moderate main effect of performance on cycling time (%) was found in the short distance (women, $p < 0.001$, $\eta_p^2 = 0.057$; men, $p < 0.001$, $\eta_p^2 = 0.035$) and the long distance race (women, $p < 0.001$, $\eta_p^2 = 0.070$; men, $p < 0.001$, $\eta_p^2 = 0.052$) (**Table 2**). Athletes in fast performance groups spent more time

TABLE 2 | Cycling time (%) spent in disciplines and transitions by distance.

	Short distance		Long distance	
Performance group	**Women**	**Men**	**Women**	**Men**
Q1	58.77 ± 1.47	58.57 ± 1.51	60.92 ± 1.63	60.19 ± 1.55
Q2	58.21 ± 1.91	57.36 ± 1.64	60.18 ± 1.74	59.33 ± 1.95
Q3	57.46 ± 1.96	56.89 ± 1.97	59.41 ± 2.00	58.54 ± 2.04
Q4	56.87 ± 2.59	56.46 ± 2.39	58.06 ± 2.56	57.46 ± 2.59

(%) in cycling than their slower counterparts, i.e., fast duathletes were relatively slow in cycling.

A small age group × performance group interaction on cycling time (%) was observed in the men's short distance (p = 0.001, η_p^2 = 0.020) with smaller differences between performance groups in the older than in the younger age groups (**Figure 2**). No interaction was shown in the women's short (p = 0.397, η_p^2 = 0.042) and long distance race (p = 0.358, η_p^2 = 0.044), and in the men's long distance race (p = 0.256, η_p^2 = 0.011).

DISCUSSION

The main findings of the present study were that (a) men were faster and older, and spent less time (%) in cycling than women in both distances; (b) athletes in older age groups spent less time (%) in cycling than their younger counterparts; (c) athletes in fast performance groups spent more time (%) in cycling than their slower counterparts; and (d) smaller differences between performance groups in the older than in the younger age groups were observed in the men's short distance.

Sex Difference in Race Time, Age and Pacing by Distance

The faster race time in men than women was in agreement with previous studies on sex differences in endurance and

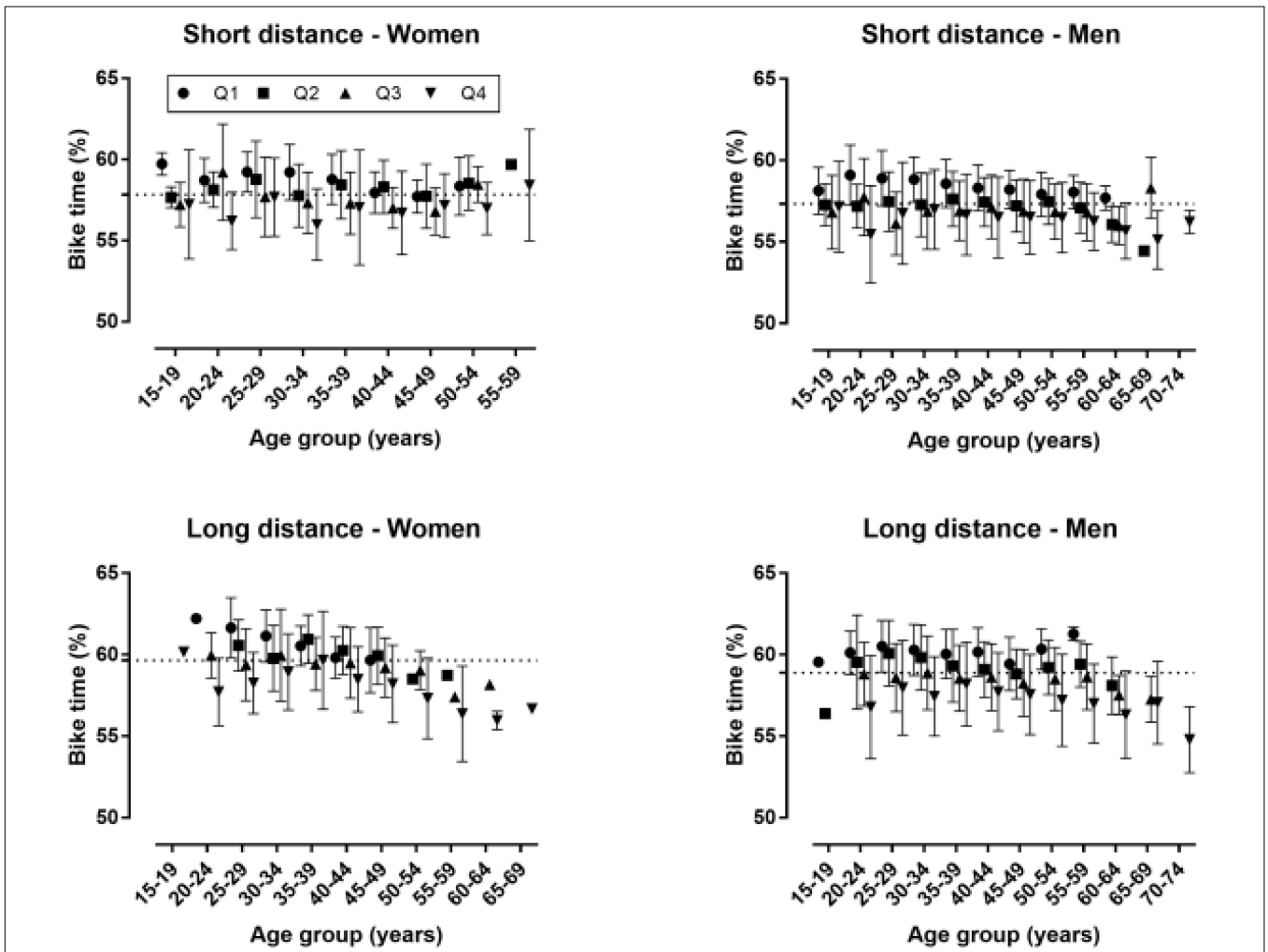

FIGURE 2 | Cycling time (%) by age, performance group, sex, and distance. Q = quartile groups based on race time with Q1 the fastest and Q4 the slowest.

ultra-endurance sport disciplines, e.g., 50 km ultra-marathon running (Nikolaidis and Knechtle, 2018a) and 6h to 10 days races (Knechtle et al., 2016). The observed sex difference in duathlon performance should be attributed to the physiological correlates of race time in this sport, such as maximal oxygen uptake (Moncada-Jimenez et al., 2009; Berry et al., 2016), where men outscored women. Furthermore, the older age of men than in women confirmed existing research in ultra-endurance running (Nikolaidis and Knechtle, 2018a). An explanation of this sex difference might be the smaller rates of women participation, especially in the older age groups. In addition, the present study was not the first to highlight sex difference in pacing in a multi-sport, as such differences have been already observed in Ironman triathlon (Angehrn et al., 2016).

Age Difference in Pacing

The less time (%) spent by older age groups in cycling compared to younger age groups indicated that older duathletes were relatively (%) faster in cycling than their younger peers. The observed age-related difference in pacing was in agreement with previous observation on the decline on physiological correlates of performance with aging in triathlon (Wu et al., 2014). Performance in duathlon was characterized by high levels of aerobic capacity (Berry et al., 2016), which in turn might influence fatigue development and the distribution of energy across race. Furthermore, it has been previously observed that performance in duathlon decreased with age (Nikolaidis et al., 2018) and the age-related decline in the duathlon performance was more pronounced in running than in cycling (Rust et al., 2013). The larger effect of aging on running than in cycling has been also shown in comparisons of United States records by age in sport disciplines involving these two locomotion modes (Ransdell et al., 2009). An explanation of the weaker effect of aging on cycling performance than in running might be the larger contribution of technology on the former than the latter locomotion mode (Neptune et al., 2009).

Combined Effect of Age and Performance on Pacing

An age × performance interaction on pacing was observed only in men for the short distance. It should be reported that, despite no statistically significant, the comparison in the long distance and in women revealed similar effect sizes for the age × performance interaction on pacing, indicating that the lack of statistical significance might be attributed to the small sample sizes in women and longer distance. An interpretation of the smaller differences in pacing among performance groups in the older groups might be that pacing correlated with race time and since differences in race time decreased across age groups, it would be expected that differences in pacing decreased, too. With regards to the role of performance level on pacing, it should be highlighted that fast duathletes were relatively faster in running than in cycling indicating that they redistributed their muscular effort in favor of running. Recently, it was shown that running economy could be improved with running-specific training, whereas cycling-specific training could not enhance cycling economy of endurance athletes (Swinnen et al., 2018). Furthermore, women triathletes could achieve higher cardiorespiratory performance in running than in cycling exercise testing (Snoza et al., 2016). These observations of previous studies might partially explain the relatively better performance of the fastest duathletes in running than in cycling.

Limitations, Strength and Practical Applications

The findings of the present study might be limited by the specific characteristics of "Powerman Zofingen," i.e., the separate distances of cycling and running. As differences were observed in pacing between the short and long version of this race, caution would be needed to generalize the findings to other duathlon races differing for total distance as well as for the separate distances of cycling and running. Moreover, it should be highlighted that age groups of either youngest or oldest duathletes were consisted of small sample size. On the other hand, strength of the study was its novelty as it was the first to examine the age × performance interaction on pacing in this sport. Considering the popularity of duathlon, as shown by the increased rates of participation in races of this sport as well as by its use as exercise protocol to study acute physiological responses to combined cycling and running (Berry et al., 2016; Finger et al., 2018), the findings would be of great practical interest for practitioners working with duathletes. Coaches in multi-sports, such as duathlon and triathlon, might train athletes differing for sex, age and performance level; thus, they should acknowledge the variation of pacing between women and men, young and old, fast and slow duathletes, and accordingly, should develop optimal pacing strategies for their athletes. For instance, since fast duathletes were relatively faster in running than in cycling, slow duathletes should be encouraged to cycle slower and run faster.

CONCLUSION

In summary, women, young and fast duathletes were relatively slower in cycling than men, old and slow duathletes; that was, old duathletes were relatively faster in cycling than in running. Moreover, there was indication that the difference in pacing among performance groups might be attenuated with aging. Therefore, the distribution of effort between the disciplines of duathlon depended on sex, age and performance level, which was of practical relevance for coaches and fitness trainers.

AUTHOR CONTRIBUTIONS

PN performed the statistical analyses and drafted the manuscript. HC, RR, and TR helped in drafting the manuscript. EV collected all the data. BK designed the study and helped in drafting the manuscript. All authors have read and approved the final manuscript.

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Gain-Framed Messaging for Promoting Adult Sport: Examining the Effects of Efficacy-Enhancing Information

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Sport is a potential venue for more middle-aged adults to engage in sufficient physical activity for health benefits. Little is known about whether messaging interventions can motivate sport activity. This experiment tested the impact of gain-framed messaging (i.e., information about the benefits of doing adult sport) based on the inclusion (or lack thereof) of efficacy-enhancing information. Adults (30–69 years-old) were randomly assigned to experimental (a 4-min online video of "Gain-framed messages alone," or "Gain-framed plus efficacy-enhancing messages") or control conditions. Participants (N = 232; 62.5% female) completed baseline measures for intentions, barrier and scheduling self-efficacy, outcomes expectancies (OEs), sport behavior and moderate-to-vigorous physical activity, received their condition 1-week later, reported measures immediately after, and 1-month later. Results showed no differences between the experimental conditions, indicating there was no advantage of supplemental efficacy-enhancing information compared to gain-framed messages alone. When the two messaging groups were collapsed, they showed significant increases for OEs related to travel, social affiliation, and stress relief immediately following experimental exposure, compared to the control group. Overall, there were few benefits attributed to messaging and no effects on self-reported sport registration or sport behavior. Discussion focuses on future messaging considerations that may more effectively motivate adult sport participation.

Keywords: gain-framed messaging, self-efficacy, adult sport promotion, outcome expectancies, sport behavior, masters sport promotion

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INTRODUCTION

Understanding how to best communicate information about the benefits of regular physical activity (PA) and the conditions under which such information persuades people to become more active is important for interventions in health. The communication of gainful messages and health outcomes relating to adult exercise, fitness and PA has been a popular area of study (Brawley and Latimer, 2007); however, strategies for specifically communicating gainful attributes of adult sport have received almost no attention. Considering that sport may be a viable conduit for community health for an ever-increasing segment of our population (Khan et al., 2012), the current experiment investigated gain-frame *messaging* applied to adult sport.

Messaging is a technique for framing the presentation of persuasive/motivating messages to stimulate engagement in desirable behaviors (Rothman and Updegraff, 2010). Unlike loss-framed messages (LFM) that highlight costs of not performing a target activity, gain-framed

messages (GFM) emphasize anticipated favorable circumstances associated with performing it. GFM are generally more effective when promoting PA (O'Keefe and Jensen, 2007; Gallagher and Updegraff, 2012), with evidence showing their effectiveness for changing psychological and behavioral outcomes (e.g., Brawley and Latimer, 2007; Berenbaum and Latimer-Cheung, 2014). In light of the fact that almost all GFM research in PA has been focused on exercise, fitness, and rehabilitative domains, this investigation sought to examine various messaging formats for promoting adult sport to middle-aged adults.

Researchers have stressed the importance of understanding various conditions that enhance messaging effectiveness for PA (Latimer et al., 2010; Hatchell et al., 2013). GFM have been shown to effectively communicate information to increase awareness/knowledge of anticipated benefits of PA, though this has not always been enough to stimulate actual behavior change in recipients. For instance, Cavill and Bauman (2004) discussed the importance of increasing knowledge and awareness for eventual behavior change, yet noted that self-efficacy needed to be additionally targeted to motivate behavior change. Furthermore, paired messaging interventions, wherein GFM were coupled with approaches that targeted additional cognitive correlates of behavioral change, appeared to have greater capability in eliciting behavioral outcomes (Latimer et al., 2008; Sweet et al., 2014). In particular, Latimer et al. (2010) suggested greater promise for interventions that pair content targeting self-efficacy (SE) beliefs with GFM. The current study investigated the pairing of GFM and SE conditions for the promotion of adult sport.

Few randomized-controlled experiments have systematically analyzed effects of supplementing GFM with an efficacy enhancement condition. Graham et al. (2006) examined the effects of pairing SE-enhancing information with GFM about the ability of exercise to decrease the risk of colon cancer in a sample of low-active adults (*M age* = 43). Compared to a control group (that received information about diet and cancer), experimental participants reported higher response efficacy and intentions to exercise. Latimer et al. (2008) investigated the relative effectiveness of GFM and LFM in adults (19–69 years old). Participants in both conditions also received message content designed to increase SE for overcoming barriers to PA. Results showed an advantage for the GFM condition in increasing intentions to be active, SE, and PA compared to LFM. Sweet et al. (2014) examined GFM paired with efficacy-enhancing messages about action planning for PA among inactive adults (*M age* = 41). This paired messaging group was equally likely as a GFM-alone group to create action plans, but their plans were significantly more detailed. These studies suggested that paired messaging conditions enhancing SE could possibly facilitate positive change on key outcomes. However, none of these studies systematically contrasted the effects of a paired (GFG+SE) condition to each of a GFM-alone and a control condition, to more systematically tease out contributions.

Only one study has used a messaging framework to promote sport participation (Lithopoulos et al., 2015). Researchers assessed the effects of a GFM intervention highlighting benefits of adult sport to 40–59 year-olds who were not regularly doing sport. Participants who viewed a GFM video, as opposed to a comparison group (quiz about sport and PA), elaborated significantly more about a hoped-for sport self on themes that were consistent with the GFM video. GFM recipients also requested significantly more sport-related newsletters, and were more likely to have registered for a sport program 1 month later. In a posteriori analyses, Lithopoulos and Young (2016) discussed how their protocol inadvertently created "paired" and "unpaired" conditions with the addition of a possible selves protocol (PSP), and how there were enhanced benefits for GFM+PSP recipients compared to those who received GFM alone, whereby they requested more newsletters and reported higher registration rates. This study showed some promising results in sport, and trends indicating an advantage for GFM in a paired condition. There remains a need to examine whether a GFM and SE-enhancing pairing might promote different outcomes for attracting middle-aged persons to sport.

OBJECTIVES AND HYPOTHESES

The current experiment aimed to answer three questions: (1) What are the psychological effects (on outcome expectancies, intentions, SE) of a GFM-alone condition compared to a paired (GFM+SE-enhancing information) condition?; (2) How are sport behavior and moderate-to-vigorous physical activity (MVPA) impacted after exposure to GFM-alone compared to GFM+SE?; (3) What are the psychological and behavioral effects of receiving *either* messaging condition (GFM-alone or GFM+SE) compared to a control condition? These questions were examined immediately after exposure and at 1-month post intervention. The hypotheses were: the GFM+SE condition would result in higher SE beliefs than GFM-alone; the GFM+SE condition would report higher intentions, rates of sport registration, sport activity and MVPA, and be more likely to request a sport-related newsletter than GFM-alone; GFM+SE and GFM-alone would report increases in outcome expectancies (OEs); GFM+SE and GFM-alone would show greater increases in psychological and behavioral outcomes than Control.

METHOD

Participants

Participants were recruited from various sources in Canada, including at community centers and at youth sport events, and via social media platforms (e.g., Facebook) and online boards (e.g., Kijiji). All participants provided informed consent and partook voluntarily. A total of 603 participants initially completed the first of three surveys. Of these, 475 (61.9% female; *M age* = 45.93, *SD* = 7.92) met inclusion criteria—they were 30–69 years-old and did not perceive adult sport to be risky ($\leq$5 on a scale from 1— "not at all risky" to 7 — "extremely risky"). Pragmatically, it does not make sense to test gain-frame messaging (in essence, a persuasive advertisement) for a target audience that reports that prospective sport activity is inherently personally risky. Thus, prior to randomized assignment, the

decision was made to not include participants who reported 6 or 7 on the perceived risk scale[1].

Procedure and Data Collection

All protocol were approved by the research ethics board at the host institution. All survey items, as well as the messaging interventions, were implemented using FluidSurveys.com.

Time 1

Recruited participants were emailed the link for the first online survey. They completed demographic and inclusion criteria measures, questions assessing stage of change (Prochaska et al., 1992) with respect to sport, health status ("Do you currently consider yourself healthy enough to regularly participate in sport?"; yes/no), and sport engagement during youth (yes/somewhat/no). They then completed dependent measures for weekly sport behavior, MVPA, intentions, barrier SE, scheduling SE, and OEs.

Typical weekly sport behavior in the past month was assessed using a modified version of the Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH; Wendel-Vos et al., 2003). Participants listed each of the sports they engaged in during an average week, then reported how many times weekly and how much time (in minutes) they attributed to each, as well as whether engagement was of light, moderate or intense effort[2]. These scores were then used to dichotomously code participants as either "yes" (participating in sport) or "no." *MVPA* was assessed using the Godin Leisure Time Exercise Questionnaire (GLTEQ; Godin and Shephard, 1985), which measured engagement in a typical 7-day period without distinguishing sport from exercise/fitness activities.

Intentions were measured using five items on a 7-point Likert scale previously used to assess messaging outcomes (Lithopoulos et al., 2015). For example, items asked "How likely is it that you will participate in sport activity sometime soon?" and "If faced with the decision to begin regular participation in sport today, how likely is it that you would do so?" This scale had high internal consistency in our sample ($\alpha = 0.92$).

Barrier SE was assessed using five items, each asking about a barrier to sport participation (i.e., lack of time, lack of motivation, negative attitude, lack of sport facilities/opportunities, lack of encouragement from others). As per Bandura (2006) guidelines, participants indicated from 0 to 100 (in increments of 10) their confidence in their ability to overcome each barrier. For example, they judged their confidence to regularly participate in sport (defined as three of more times per week for at least 150 min) "When I have other time commitments." The 5-item scale showed acceptable reliability ($\alpha = 0.77$). *Scheduling SE* was measured to derive an index of confidence in one's ability to schedule increasing amounts of sport activity. After the prompt, "Assuming you are motivated, in the next month, how confident are you that you can fit at least 30 min of moderate-to-heavy intensity sport participation into your weekly schedule," participants responded on a Likert scale (1 = "not at all confident" to 7 = "completely confident") for different options (once; twice; three; four; five, or more times per week; see Arbour-Nicitopoulos et al., 2009, for validity of this protocol with adults). The scale had strong reliability in our sample ($\alpha = 0.93$).

OEs were assessed to derive an index of beliefs about the likelihood that regular sport participation would result in favorable outcomes (Gellert et al., 2012). Participants judged items for nine gainful outcomes (each one matched a message in our GFM): *optimal health (OE-Health)*; *delayed effects of aging (OE-Aging)*; *social affiliation (OE-Friends)*; *fun/enjoyment (OE-Fun)*; *stress relief (OE-Stress relief)*; *improvement of physical capabilities (OE-Physical capabilities)*; *thrills/excitement (OE-Thrills)*; *achievement of competitive goals (OE-Goals)*; *travel opportunities (OE-Travel)*. For example, in response to "Regularly participating in sport can give me the opportunity to make new friends," participants made judgments on a Likert scale (1 = "strongly disagree" to 5 = "strongly agree"). Pearson correlations between the nine OE items at T1 (all <0.70) revealed that multicollinearity was not a concern; thus, each OE was treated as a separate dependent variable.

A possible covariate, *attitudes toward adult sport*, was assessed with a semantic differential scale (Berenbaum and Latimer-Cheung, 2014) modified for sport. Participants made Likert scale responses to the prompt, "For me, regularly participating in sport as an adult would be" according to seven anchors: good—bad; beneficial—harmful; valuable—worthless; enjoyable—unenjoyable; pleasant—unpleasant; interesting—boring; relaxing—stressful. The scale had strong reliability ($\alpha = 0.90$).

Time 2

After completion of the T1 survey, each consecutive suite of five responders that met inclusion criteria for age and perceived risk was assigned randomly to groups in a 2-2-1 fashion (i.e., 2 respondents to GFM-alone, 2 to GFM+SE, 1 to the control). Participants were sent an email inviting them to open a web-link

[1]Both Tversky and Kahneman (1981) and Rothman and Salovey (1997) discussed how prospective gain-framed messages may be received differently depending on whether prospective gain-frame outcomes are viewed as certain or as risky, i.e., not certain or encumbering some risk in the pursuit of gain-frame conditions. This interaction of gain-frame messaging and risk has received little attention and we did not set out to address this interaction explicitly in the current experiment. However, it was important to screen for risk to ensure (a) our targeted audience for the intervention did not see the criterion behavior as inheriting undue personal health risk, and (b) that there were non-significant differences between our experimental groups at baseline.

[2]Although the SQUASH self-report procedure is purported to derive continuous data, inspection of our returned data showed highly non-normal distributions across the entire sample, and within groups. This was likely because the SQUASH asks people to list activities in a drop-down box and then, for each activity, to report commensurate scores in boxes to estimate frequency and intensity of engagement in that activity. In essence, an individual's insertion of a categorical variable is multiplied by scaled indices for frequency and intensity to arrive at a SQUASH score. When no categories are inserted representing sport, then there is no multiplication, and the distributions take on a bi-modal pattern, with one end of the distribution showing a prevalence of zero scores. At the other end of the distribution, for those who inserted one or more sport activities, there is greater variability of sport activity data. This led to the decision to score participants data as 'yes' or 'no' to sport activity.

to view their intervention (GFM-alone or GFM+SE). Control participants did not receive any messaging; they opened their web-link and completed the survey measures.

GFM-Alone

Participants received a 4-min narrated PowerPoint Presentation (PPT) video with nine consecutive GFM, each highlighting a benefit of being involved in adult sport, followed by five neutral slides. Messages were tailored to each person's sex by assigning a female/male narrated voice. The GFM replicated the promoted benefits from Lithopoulos et al. (2015), taken from research on involvement opportunities gained through adult sport participation (Young et al., 2015; see **Appendix A** in **Supplementary Material** for messages). There were neutral slides that were added containing factual/historical information about adult sport to ensure both experimental conditions received the same number of messages in a video of the same length. Message order was randomized, and participants were not able to pause the video such that messages were not repeated, with equal time per message.

GFM+SE

Participants received a 4-min narrated PPT video. The first nine messages were the GFM in a randomized order, followed by five randomized SE messages, each designed to increase SE to regularly participate in sport when faced with a common barrier, by suggesting a technique to overcome each barrier. After extensively reviewing the most common barriers to adult sport (e.g., Cardenas et al., 2009), five SE-enhancing messages for navigating barriers were created, specifically pertaining to: lack of time; lack of motivation; negative attitudes; lack of sport facilities/opportunities nearby; lack of encouragement from others. Each message comprised phrasing reflecting vicarious (e.g., "other adults just like you have done it") and verbal persuasive ("you too can do it") efficacy enhancement sources (Bandura, 2001; see **Appendix B** in **Supplementary Material**).

Immediately Following Video Exposure

Experimental participants were asked to type out two main themes they recalled being presented in the messages. The primary investigator reviewed the responses from each participant (i.e., what they had typed in an open-ended box) and coded distinct themes, enumerated them (0, 1, or 2 or more themes being recalled). This served as a manipulation check; 12 participants (*GFM-alone* = 7; *GFM+SE* = 5) could not recall two themes and were excluded from the analyses.

Time 2 Survey Measures

All participants reported intentions, barrier SE, scheduling SE, and OEs. They were also asked whether they would like to request *a newsletter relating to adult sport opportunities* in their community (yes/no), which is a proxy measure for interest and information-seeking (Lithopoulos et al., 2015).

Time 3

Four weeks later, participants reported intentions, barrier SE, and scheduling SE, as well as weekly sport behavior, weekly MVPA, whether they had *registered for a sport program* (e.g., an organization, team, club; yes/no), and whether they had *registered for a sport event* (e.g., a local 10 km race; yes/no) within the past month.

ANALYSES AND RESULTS

Preliminary Analyses

Each dependent variable at baseline was inspected for normality. *OE-Health* showed evidence of skewness (−2.27) and kurtosis (4.90), and the *OE-Aging* had some kurtosis (2.20), but all other variables showed skewness and kurtosis values $< \pm 2$ (Field, 2005). Analyses were performed to inspect outliers all on dependent variables at T1. The MVPA scores of three participants revealed them as extreme outliers (>3.29 *SD*); they were excluded from further analyses. Baseline equivalency tests were performed to inspect group differences at T1 for participants who completed the entire study. The groups were not significantly different (see **Table 1**), except more control participants perceived themselves as *not* healthy enough to regularly participate in sport ($p < 0.001$). Although some participants judged themselves not healthy enough for sport, their GLTEQ data showed high activity levels in other forms of PA. As such, there was little concern about risk, so the decision was made to conduct and report all main analyses with the total sample, irrespective of their health status judgments To confirm our results were replicated with the smaller cohorts that reported being "healthy enough" to regularly participate in sport, all analyses were re-run with only those participants in each group. Results were the same for the healthy-enough sample, as were effect sizes, with two exceptions that are identified in subsequent endnotes[3]. With respect to the dependent variables (see **Tables 2**, **3** for descriptives), there were only two between-group differences at T1: *OE-Fun* ($p = 0.02$) and *OE-Physical capabilities* ($p = 0.02$).

Bivariate correlations were conducted to determine potential covariates (Tabachnick and Fidell, 2012). T1 *attitudes toward sport* correlated strongly with *intentions* (r =0.64) and moderately with the *OEs* (ranged from 0.15 to 0.54); considering theoretical rationale that attitudes toward an activity affect intention (Azjen, 1991), *attitudes* became a covariate for all analyses pertaining to intentions and OEs. Due to moderate-to-strong correlations, T1 *intentions* were identified as a covariate for analyses pertaining to *barrier SE* ($r = 0.33$), *MVPA* ($r = 0.53$), and *scheduling SE* ($r = 0.59$).

Attrition Analyses

A total of 475 participants completed the T1 survey and were eligible for the study, 244 completed the T2 survey, and 232 completed T3. Tests were performed, for the entire sample and on a within-group basis, to compare T1 characteristics between participants that completed the entire study and those that dropped out at some point. Analyses for the entire sample

[3]To confirm our results were replicated with the smaller cohorts that reported being "healthy enough" to regularly participate in sport, all analyses were re-run with only those participants in each group. Results were the same for the healthy-enough sample, as were effect sizes, with two exceptions that are identified in subsequent endnotes.

TABLE 1 | Descriptive statistics for demographic and screening variables at baseline.

	GFM-alone	GFM+SE	Control
N	79	84	69
Mean age (*SD*)	47.3 (8.13)	47.9 (7.32)	44.7 (10.3)
Gender (male, female, other)	30, 48, 1	32, 50 (2 missing)	47, 21
Mean risk perception (*SD*)	2.62 (1.43)	2.55 (1.43)	2.93 (1.43)
PERCEIVED HEALTH STATUS			
Healthy (%)	87.3	85.5	63.8
Not healthy (%)	12.7	14.5	36.2
WEEKLY SQUASH SPORT STATUS			
Active in sport (%)	32.9	35.7	24.6
Not active in sport (%)	67.1	64.3	75.4
YOUTH SPORT PARTICIPATION			
Yes (%)	58.2	57.1	58.0
Somewhat (%)	15.2	11.9	8.7
No (%)	25.3	25.0	31.9
Missing data (%)	1.3	6.0	1.4
STAGE OF CHANGE			
1–Pre-contemplation (%)	43.1	36.9	53.6
2–Contemplation (%)	13.9	14.3	13.2
3–Preparation (%)	6.3	9.5	1.4
4–Action (%)	5.1	3.6	2.9
5–Maintenance (%)	29.1	35.7	27.5
Missing data (%)	2.5	0.0	1.4

TABLE 2 | Descriptive statistics for outcome expectancy variables at multiple time points.

		Time 1		Time 2	
Group		**Mean**	***SD***	**Mean**	***SD***
GFM-alone	OE-Health	4.46	1.04	4.51	0.87
	OE-Aging	4.19	1.02	4.35	0.77
	OE-Friends	3.95	1.04	4.09	0.87
	OE-Fun	4.01	1.17	3.97	1.00
	OE-Stress relief	3.90	1.13	3.82	1.13
	OE-Physical capabilities	3.95	1.10	4.15	0.92
	OE-Thrills	3.53	1.06	3.71	1.09
	OE-Goals	3.24	1.17	3.58	1.12
	OE-Travel	2.63	1.35	3.04	1.16
GFM+SE	OE-Health	4.59	0.84	4.57	0.91
	OE-Aging	4.41	0.93	4.30	0.96
	OE-Friends	3.94	1.05	4.17	0.82
	OE-Fun	4.34	0.98	4.14	0.96
	OE-Stress relief	4.29	0.96	4.19	0.94
	OE-Physical capabilities	4.34	0.83	4.29	0.80
	OE-Thrills	3.76	1.15	3.76	0.94
	OE-Goals	3.52	1.11	3.57	1.15
	OE-Travel	2.77	1.20	3.10	1.17
Control	OE-Health	4.51	0.87	4.45	0.82
	OE-Aging	4.25	1.01	4.24	0.93
	OE-Friends	4.09	0.90	3.91	0.94
	OE-Fun	3.88	1.11	3.75	1.18
	OE-Stress relief	4.07	1.09	3.72	1.18
	OE-Physical capabilities	3.96	1.06	4.03	0.97
	OE-Thrills	3.45	1.19	3.32	1.11
	OE-Goals	3.31	1.22	3.34	1.22
	OE-Travel	2.91	1.15	2.69	1.16

showed differences between "completers" and "drop-outs" for *group assignment, age, weekly sport behavior*, and six *OEs* (all *p*s < 0.03). GFM-alone (drop-outs = 41.2%) and GFM+SE (39.5%) participants were more likely than control participants (19.3 %) to drop-out. Completers were older than drop-outs within the GFM+SE group (completers: $M = 47.9$, drop-outs: $M = 44.8$) and within the GFM-alone group (completers: $M = 47.3$, drop-outs: $M = 44.8$). Drop-outs were likelier to report some current sport-related participation (74.8%) than completers (31.5%), which also held true in each group. Control group completers were likelier to have not participated in youth sport (no = 32.5%; somewhat participated = 8.8%; participated in youth sport = 58.5%) than drop-outs (no = 4.5%; somewhat = 27.3%; participated in youth sport = 4.5%). For the entire sample, and within the Control group, drop-outs reported higher OEs for Fun, Stress relief, Physical capabilities, Thrills, Goals, and Travel than completers at T1.

Main Analyses

Did the GFM-Alone and the GF+SE Conditions Elicit Different Effects?

Immediate effects

A series of Group × Time (T1, T2) repeated-measures analysis of covariance (RM-ANCOVAs) compared trends between the experimental groups in *OE* responses. No significant interaction effects were found for any of the separate analyses for the nine *OE* variables (*Health,* $p = 0.75$; *Aging,* $p = 0.10$; *Friends,* $p = 0.97$; *Fun,* $p = 0.23$; *Stress relief,* $p = 0.51$; *Physical capabilities,* $p = 0.14$; *Thrills,* $p = 0.28$; *Goals,* $p = 0.11$; *Travel,* $p = 0.70$). A binary logistic regression tested if assignment to one of the groups better predicted *requests for a sport-related newsletter* (controlling for T1 intentions). The model was not significant, $X^2_{(2)} = 1.91$, $p = 0.38$, Nagelkerke $R^2 = 0.01$.

Outcomes across three time points

Separate Group × Time (T1, T2, T3) RM-ANCOVAs were performed for *intentions*, *barrier SE* and *scheduling SE*. No significant interactions resulted: *intentions* [$p = 0.65$, $\eta^2_p = 0.00$], *barrier SE* ($p = 0.36$, $\eta^2_p = 0.01$), *scheduling SE* ($p = 0.54$, $\eta^2{}_p = 0.01$). A Group x Time (T1, T3) RM-ANCOVA was conducted for *MVPA* scores, resulting in a non-significant interaction ($p = 0.88$, $\eta^2_p = 0.00$). Finally, a chi-square tested group differences in the frequency of *weekly sport activity* designations (yes/no) at T3, using T1 sport activity categorization (yes/no) as a control variable. There was no group difference, [$X^2_{(1)} = 2.0$, $p = 0.15$, Cramer's V = 0.12; % active in sport: GFM+SE = 29.9%; GFM-alone = 41.9%. Results showed that those in both experimental groups that were not active in sport at T1 were equally as likely to report sport activity at T3,

TABLE 3 | Descriptive statistics for self-efficacy, intentions and MVPA variables at multiple time points.

		Time 1		Time 2		Time 3	
Group	**Variable**	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
GFM-alone	Barrier SE	50.4	23.1	49.5	20.6	52.9	19.2
	Scheduling SE	3.63	1.86	3.35	1.63	3.42	1.73
	Intentions	4.01	2.01	3.88	1.80	3.83	1.83
	MVPA (GLTEQ)	23.6	18.3	–	–	23.6	17.6
GFM+SE	Barrier SE	52.2	23.0	51.8	25.5	52.5	23.0
	Intentions	3.82	1.73	3.82	1.73	3.99	1.85
	Scheduling SE	3.76	1.85	3.68	1.65	3.66	1.70
	MVPA (GLTEQ)	27.9	19.2	–	–	29.4	20.6
Control	Barrier SE	44.6	25.9	46.8	22.7	44.1	22.6
	Scheduling SE	3.34	1.98	3.44	1.71	3.43	1.88
	Intentions	3.93	2.06	3.70	1.93	3.94	1.99
	MVPA (GLTEQ)	26.8	22.6	–	–	24.7	22.5

Mean barrier SE scores were 0–100, intentions and scheduling SE Likert-scale scores ranged from 1 to 7, and MVPA scores were composite scores from the GLTEQ, with higher values representing greater activity.

[$X^2_{(1)} = 0.94$, $p = 0.33$, Cramer's V = 0.10; % active in sport: GFM+SE = 9.5%; GFM-alone = 16.7%.

Outcomes measured only at 1-month follow-up

For participants not active in sport at T1, separate binary logistic regressions examined if assignment to one group better predicted *registration in a sport program* and *registration in a sport event*, while controlling for T1 intentions. Although the model for program registration was significant, $X^2_{(2)} = 11.29$, $p < 0.001$, Nagelkerke $R^2 = 0.15$, *post-hoc* examination indicated "Group" did not contribute to variance in registration frequency ($p = 0.64$, $B = 1.2$). The model for event registration was non-significant, $X^2_{(2)} = 1.87$, $p = 0.39$, Nagelkerke $R^2 = 0.03$.

Comparing a Collapsed Intervention Group to the Control Group

Since the experimental groups acted similarly, the groups were collapsed (called the "Intervention" group) and submitted to the same aforementioned series of analyses contrasting the Intervention to the Control group.

Immediate effects

Results revealed interaction effects for *OE-Travel* [$F_{(1,219)} = 12.3$, $p < 0.001$, $\eta^2_p = 0.05$], *OE-Friends* [$F_{(1,217)} = 5.30$, $p = 0.02$, $\eta^2_p = 0.02$], and *OE-Stress relief* [$F_{(1,217)} = 3.78$, $p = 0.05$, $\eta^2_p = 0.01$] (see **Figures 1A–C**). *Post-hoc* pairwise comparisons revealed the Intervention group reported increased expectations of sport to provide travel opportunities at T2 compared to T1 ($p < 0.001$, $\eta^2_p = 0.07$), and they had higher OE-Travel than the Control at T2 ($p = 0.03$, $\eta^2_p = 0.02$). *Post-hoc* comparisons for *OE-Friends* showed the Intervention group increased their expectations about sport providing opportunities to make new friends at T2 compared to T1 ($p = 0.03$, $\eta^2_p = 0.02$). The Control group did not change over time ($p = 0.17$), and the Intervention and Control groups were not different at T2 ($p = 0.14$). Pairwise comparisons for *OE-Stress relief* revealed the Control group decreased their expectations from T1 to T2 ($p < 0.001$, $\eta^2_p = 0.03$), whereas the Intervention group did not decrease over time ($p = 0.61$); the groups were not different at T2 ($p = 0.12$). There were no significant interactions for the other OEs[4]. Generally, the Intervention group consistently trended positively in OEs over time, while Control group values remained constant or slightly decreased (**Table 2**).

With respect to *requests for a sport-related newsletter*, the model was significant, $X^2_{(2)} = 10.94$, $p < 0.001$, Nagelkerke R^2 =0.06; however, "Group" did not contribute to variance in frequency of requests ($p = 0.15$, $B = 0.65$).

Outcomes across three time points

Results showed non-significant interactions for *intentions*, *barrier SE* and *scheduling SE* (all *ps* > 0.45). There was a main effect for time for *scheduling SE* [$F_{(2,\ 316)} = 2.94$, p =0.05, $\eta^2_p = 0.01$], whereby levels decreased significantly at successive time points for all participants. Results for *MVPA* showed an interaction approaching significance [$F_{(1,180)} = 3.13$, $p = 0.07$, $\eta^2{}_p = 0.01$][5]. Although none of the pairwise *post-hoc* tests reached significance (all *ps* > 0.12), the Control group showed decreased trends for MVPA from T1 to T3, while the Intervention group increased slightly. There was no group difference for frequency of *weekly sport behavior* at T3, $X^2_{(1)} = 0.85$, $p = 0.35$, Cramer's V = 0.06; % active in sport: Intervention = 35.7%; Control = 28.8%. Among participants who were not active in sport at T1, the Intervention and Control groups were equally likely to report sport activity at T3, $X^2_{(1)} = 0.10$, $p = 0.74$, Cramer's V = 0.02; % active in sport: Intervention = 13.1%; Control = 11.1%.

Outcomes Measured Only at 1-Month Follow-up

With respect to *sport program registration*, the model was non-significant, $X^2_{(2)} = 2.69$, $p = 0.26$, Nagelkerke $R^2 = 0.10$. The model for *event registration* was significant, $X^2_{(2)} = 10.71$, $p < 0.001$, Nagelkerke $R^2 = 0.11$, but "Group" did not significantly contribute to variance in registration ($p = 0.27$, $B = 0.58$).

DISCUSSION

No Significant Differences Between the Two Experimental Groups

Directly after exposure, participants in the GFM-alone and GFM+SE groups reported similar OEs and were equally as likely to seek a sport-related newsletter. After exposure

[4]The same analyses for "healthy enough" participants revealed one novel significant result for *OE-Thrills*, $F_{(1,173)} = 3.95$, $p = 0.04$, $\eta^2_p = 0.02$. Trends indicated the Intervention group had increased expectations and the Control group decreased in expectations for thrills from T1 to T2.

[5]The same analysis for "healthy-enough" participants indicated a significant group by time interaction effect for *MVPA*, $F_{(1,145)} = 4.79$, $p = 0.03$, $\eta^2_p = 0.03$. Post-hoc tests revealed that GLTEQ scores decreased from T1 to T3 for the Control group ($p = 0.05$, $\eta^2_p = 0.02$), but scores among Intervention participants did not change ($p = 0.32$).

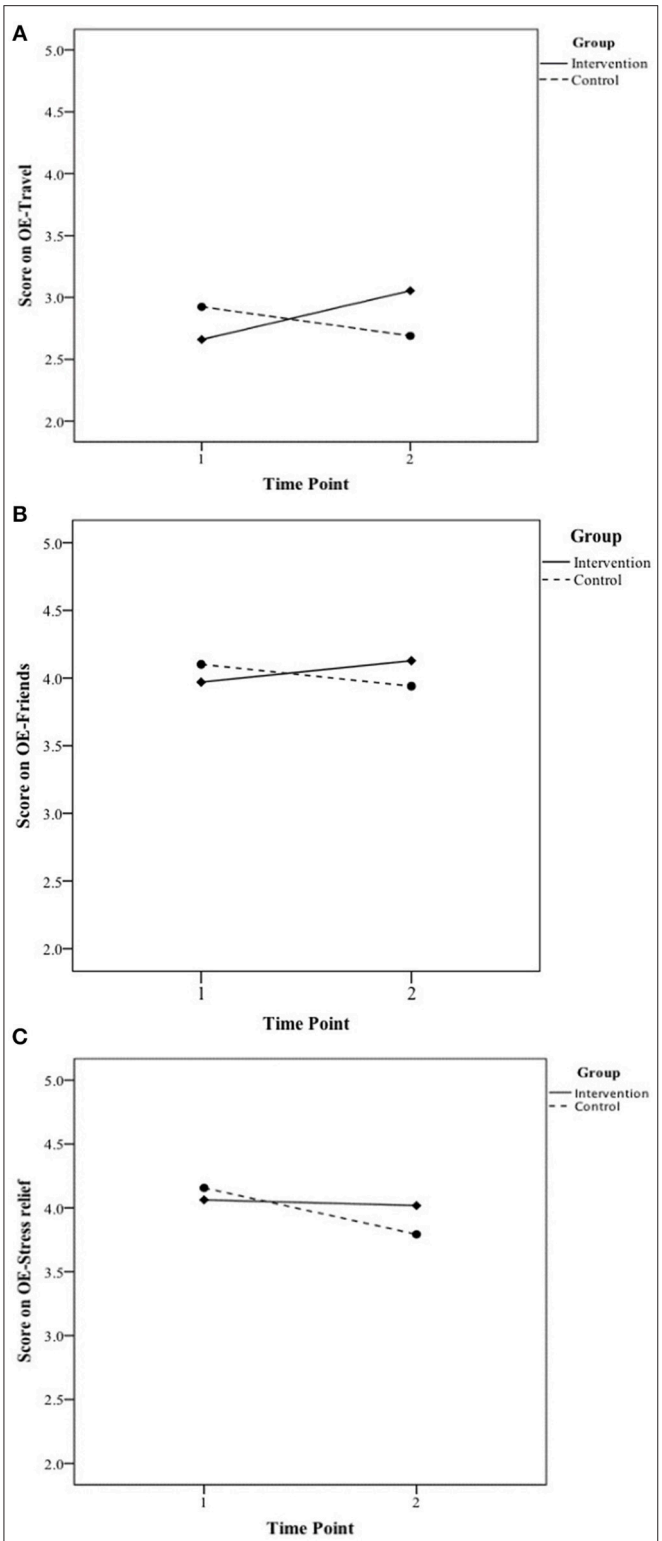

FIGURE 1 | Results for significant group by time interactions found when comparing a collapsed Intervention group (comprising GFM-alone and GFM+SE) to the Control group. **(A)** Represents expectancies to experience opportunities to travel, **(B)** Represents expectancies to have opportunities to be with friends, and **(C)** Represents expectancies to relieve stress via regular adult sport participation.

and at the 1-month follow-up, both groups reported similar intentions to do sport, barrier SE, scheduling SE, and similar MVPA levels. Participants in both experimental groups also reported similar rates of sport participation, and registration in sport programs and events. Thus, contrary to our hypotheses, there was no advantage for recipients of the additional efficacy-enhancing messages.

Although the efficacy-enhancing messages in the paired condition embedded mastery and vicarious SE sources, tailored directly to barriers for adults, they did not increase barrier/scheduling SE compared to the GFM-alone condition. Since 64.3% of GFM+SE participants were *not* active in sport at baseline, it is possible the messages intended to enhance efficacy may have actually reinforced the belief that there are barriers to adult sport participation. Wegner (1994) Theory of Ironic Processing posits that while a conscious thought process directs attention toward a desired behavior (e.g., sport participation), parallel "ironic" processing monitors indicators of potential failure (e.g., lack of ability to overcome barriers). Ironic processing is more automatic, less effortful, and can cause unwanted thoughts/behaviors when an individual is facing high cognitive demand. The cognitive demand of completing survey measures may have led to ironic processing; "efficacy-enhancing" messages may have paradoxically caused some participants to focus on potential failure of *not* overcoming barriers, negating any advantage from GFM+SE.

Barrier efficacy-enhancement may not be the most appropriate approach to pair with a messaging intervention when attempting to stimulate PA, at least not in the context of adult sport. Pairing GFM with other protocol may be more effective. Lithopoulos and Young (2016) paired GFM with an identity-elaboration ("possible sport selves") protocol and found benefits for enhanced sport-specific information-seeking behavior and sport registration, and significant increases in sport intentions. Sweet et al. (2014) paired GFM with messages designed to increase motivation for action planning and found that higher quality action plans were developed among participants in the paired condition. Having participants deliberately write about aspects of a "possible sport self" or create an action plan for PA engages individuals to a greater extent than simply reading promotional messages.

Comparing the Collapsed Experimental to the Control Condition

Psychological Outcomes

The results provided insight about the effects of receiving *either* messaging intervention (i.e., GFM+SE or GFM-alone) compared to a control condition. The Intervention group consistently trended positively in reports of OEs over time, while the Control group remained constant or slightly decreased in their reports of anticipated OEs. Specifically, the Intervention group showed significantly stronger effects for the anticipated likelihood that sport would result in travel opportunities, opportunities to make friends, and opportunities for stress relief. The largest increases over time pertained to the likelihood of adult sport to provide travel opportunities and opportunities to make new friends.

Whereas traditional messages promoting PA have often focused on widely-acknowledged health and fitness benefits, travel and social affiliation opportunities via sport may be more novel for adults, and therefore made a greater impression on the participants (Petty et al., 2009). *OE-Travel* may have seen the greatest increase among Intervention participants because it had the greatest potential for growth, as it had the lowest baseline mean of the OEs.

The many non-significant between-group results indicate that the messages were perhaps not strong enough to elicit changes in key psychological variables, or that the one-time exposure to the intervention was insufficient to significantly affect most variables (Latimer et al., 2008). It is likely that reports of OEs increased because the nine GFM specifically targeted beliefs about positive outcomes of adult sport participation, which were congruently reflected in each OE item. Although a few OEs were enhanced among experimental participants, this advantage did not appear to translate into gains in other important outcome cognitive variables (e.g., intentions). Beliefs about the benefits of sport are important in the early stages of behavior change, but additional psychological antecedents like SE and intentions should also be enhanced to actually increase behavior (Cavill and Bauman, 2004). Additional messages (or alternative sport-promotion tactics) that specifically target other key cognitive antecedents should continue to be explored to understand how to best motivate sport behavior.

Behavioral Outcomes

The frequency by which Intervention and Control participants requested a sport-related newsletter was similar immediately after exposure, as was their weekly sport behavior and sport registration 1-month later. There was a notable trend whereby MVPA levels significantly decreased from T1 to T3 for the Control group, but scores among the Intervention participants did not drop. As we collected the majority of data from November to January (predominantly winter months in Canada), participants were possibly subjected to seasonal declines in MVPA. The non-intervention Control group perhaps reflected the seasonal downturn, whereas Intervention participants may have benefitted from receiving a sport-promotion messaging intervention that "buffered" against seasonal declines. This said, this inference about sport messaging having a buffering effect on diffuse (non-sport) types of PA is admittedly tenuous (results were shy of a significant interaction for MVPA in the total sample of participants) and will need to be proven in future research. Our conclusion is that our messaging interventions designed to specifically promote sport activities did not stimulate increases in sport-specific behavior. Past messaging studies have also reported difficulty in changing PA behavior (e.g., Latimer et al., 2010); our results reinforce the challenge of motivating increases in targeted PA behaviors through messaging.

Limitations and Future Directions

This study had limitations that could be improved upon in future work. There was a high rate of attrition, which has been cited in many web-based interventions (e.g., Wangberg et al., 2008). Thus, our sample could not be targeted to the extent that has been recommended by messaging researchers (e.g., tighter age group, only individuals in early stages of change; Latimer et al., 2010; Lithopoulos et al., 2015). There remains a need to implement tactics to retain more participants in these types of interventions.

Attrition analyses allowed for better understanding of differences between those who dropped out and those who adhered throughout. Firstly, individuals assigned to an experimental condition were more likely to drop-out than those in the Control group, suggesting the added participant burden of watching a promotional video may be to blame. Secondly, individuals were more likely to complete the entire study if they had lower expectations regarding the beneficial outcomes of adult sport prior to intervention, and if they were not active in sport as an adult or during youth. Thus, it is possible that individuals that were already active in sport "turned off" this sport-promotion study, as they were sufficiently motivated to be engaged in sport activities without a messaging intervention. This explanation may also explain why adults who reported higher OEs at baseline, or those who participated in sport in youth, were more likely to drop-out. Drop-outs may have already been convinced of the benefits of sport and did not see any use for remaining within the study.

Our sport-promotion messaging intervention was not sufficient to stimulate significant increases in the majority of our outcome variables. Research should continue to investigate more effective ways to enhance key psychological and behavioral outcomes related to adult sport. Messaging literature has shifted away from providing cognitive/instrumental information (e.g., logical reasons why participation in PA is beneficial that would typify traditional GFM) to more affective-based information. For example, Sirriyeh et al. (2010) showed how people who received PA-promotional text messages targeted to affective beliefs (e.g., enjoyment) increased their PA more than those who received a set of instrumental belief messages, those who received combinations of affective and instrumental belief messages, and a control group. Recent messaging interventions for PA have documented advantages for messages focusing on affective beliefs and outcomes over cognitive-based rationale (Morris et al., 2016; Ruissen et al., 2018). Since our messages contained primarily instrumental-based information, future work could investigate the effectiveness of affective-based messages in sport.

Messaging may be more effective as part of a more holistic approach. For example, considering sponsorship/recruitment by a significant other who is already involved in adult sport is a key conduit for attracting new participants (Stevenson, 2002), tying messaging to an immediate protocol that links recipients to possible mentors/sponsors (who share similar personal attributes) may hold promise. Another direction is to deliver targeted and tailored messages about sport to personal devices (Mistry et al., 2015) or to provide persuasive messages to individuals already participating in a behavioral intervention (i.e., a program; Kinnafick et al., 2016).

DATA AVAILABILITY

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations and full ethics approval from the Health Sciences and Sciences Research Ethics Board at the University of Ottawa, Office of Research Ethics and Integrity. Written informed consent was obtained from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

ML initiated the ideation, design, and execution of this study. She led analyses, interpretation and discussion of results. BY supported ML in a supervisory role and provided feedback at all stages of research, including write-up and edits.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00431/full#supplementary-material

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An Examination of the Deliberate Practice Framework in Quad Rugby

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The deliberate practice framework was forwarded to account for the characteristics and developmental experiences of individuals who have acquired exceptional performance in any domain. This framework proposed that experts undergo an extensive acquisition period involving the accumulation of thousands of hours of deliberate practice while overcoming various constraints that serve as functional barriers to the achievement of expertise. Although the deliberate practice framework has been examined in the context of a range of domains, disability sport remains relatively unstudied. The purpose of this study was, therefore, to examine expert disability sport athletes to determine how well their experiences and characteristics were captured by the deliberate practice framework. Quad rugby players were asked to complete a two-part survey to report their recall of the amount of time spent in individual and team practice activities, quad rugby related activities, and daily life activities at the start of their careers and every 2 years since. These activities were then rated with respect to relevance to improving performance, effort and concentration required, and enjoyment of participation. Findings revealed that quad rugby athletes engaged in similar amounts of practice throughout their career to those observed in superior performers across domains, including musicians and expert performers in the able-bodied sport domain (e.g., M = 8,309 h at 9–10 year career mark). Contrary to the original deliberate practice framework and some of the subsequent examinations in sport, disability sport athletes did not rate the most relevant and effortful activities as either low or high on enjoyment. The unique constraints imposed on disabled athletes may reduce the likelihood that clear differences will emerge when considering affective responses such as enjoyment.

Keywords: deliberate practice, expertise, quad rugby, disability sport, wheelchair rugby

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INTRODUCTION

Superior performance has been documented in a wide range of human performance domains such as music and competitive sport (Ericsson and Smith, 1991). Although many people may attempt to reach such exceptional levels of performance, few have actually reached the highest levels of performance in any given domain (Ericsson, 1996). For example, about 1,700 swimmers competed in the 2016 United States Olympic Trials (Anderson, 2018) to fill a roster of about 50 athletes (USA Swimming, 2016). Less than half of team medaled in individual events. Ericsson et al. (1993) forwarded a general framework to account for the characteristics and developmental experiences of individuals who have acquired exceptional performance in a given domain. This framework

proposed that experts undergo an extensive *acquisition period* involving the accumulation of thousands of hours of *deliberate practice* while overcoming various *constraints* that serve as functional barriers to the achievement of expertise.

The presence of an extended acquisition period prior to attaining expertise was originally documented by Simon and Chase (1973) in their examination of international grandmaster chess players. Exceptional performance in this domain appeared to require at least 10 years of intense preparation. Acquisition periods of similar duration (from approximately 6,000 to 10,000 h) have also been observed in international and top-level performers across a variety of other domains including the arts, sciences, and sports (Hayes, 1981; Bloom, 1985; Ericsson and Crutcher, 1990). A more recent review (Baker and Young, 2014) found that the lower end of the range for sport expertise can be as few as about 4,000 h. Additionally, Baker et al. (2003) reported total hours as low as about 2,200. Consistent with the extended acquisition period, several studies have also noted a positive correlation between the age at which an expert begins practice in their given domain and the level of performance ultimately achieved, with international level performers typically showing the youngest starting ages (Ericsson and Crutcher, 1990; Ericsson et al., 1993; Ericsson, 1996). Ericsson and Crutcher (1990) reported that engagement in specific practice activities often begin before the age of six. Subsequent research has indicated that high level performers sometimes sample from a wide range of relevant activities prior to specializing at a later age (e.g., Cote et al., 2003; Hendry and Hodges, 2018).

According to the deliberate practice framework, however, simply practicing for an extended period of time will not automatically result in the achievement of expertise in a domain (Ericsson et al., 1993). Rather, practice activities must fit the criteria for what has been termed deliberate practice. Deliberate practice consists of specifically designed activities focused on accomplishing targeted performance goals and improving skills. Consequently, deliberate practice as originally described does not include paid work, playful interaction, and observing others. Deliberate practice activities are intentionally designed to identify weaknesses and improve aspects of performance through observation of performance results and provision of relevant feedback regarding training goals. The deliberate practice framework places equal emphasis on both the quality and quantity of practice. According to the deliberate practice framework, there is a linear relationship between the amount of deliberate practice accumulated and the level of performance attained. The so-called *monotonic benefits assumption* suggests that a person who has attained the highest level of performance in a domain will also have participated in the largest amount of time in deliberate practice. In fact, according to Ericsson et al. (1993), engagement in deliberate practice is the single most influential contributing factor in the achievement of expert performance in any domain.

During the acquisition period, developing experts must overcome three types of constraints that act to impede progress toward exceptional levels of performance (Ericsson et al., 1993). The *resource constraint* describes the necessity of acquiring access to resources such as teachers, training facilities, and training materials pertinent to the domain. Parents and guardians often play an influential role in overcoming this constraint by providing financial support, transportation, and exposure to the domain. Because of the specialized nature of deliberate practice and the duration of the acquisition period, the resource constraint can place a considerable burden on the available time and money at the disposal of an aspiring expert's family. The *effort constraint* describes the necessity that an aspiring expert must be willing and capable of devoting the mental and physical effort to maximize each practice session. For many domains, practice can require intense effort that can only be maintained for a short period of time without leading to exhaustion. For example, Ericsson et al. (1993) reported that expert musicians could only engage in about 4 h of deliberate practice activities each day. The *motivational constraint* describes the necessity that an aspiring expert must be motivated to dedicate the time and energy to practice activities that are not inherently enjoyable. Motivation is considered as essential for an aspiring expert to repeatedly produce performances of the highest quality when engaged in deliberate practice.

A strong interest in professional and international sport competition has led several researchers to examine how well the deliberate practice framework describes expertise in sports such as figure skating, wrestling, soccer, field hockey, martial arts, and middle distance running (Hodges and Starkes, 1996; Starkes et al., 1996; Helsen et al., 1998; Hodge and Deakin, 1998; Young and Salmela, 2002). These studies have focused on documenting accumulated hours of deliberate practice and athletes' ratings of relevance, effort, concentration, and enjoyment of various practice activities as a way of exploring how constraints may have influenced their practice experiences. Although these studies have generally been consistent with Ericsson et al.'s (1993) examination of expert musicians, some notable exceptions have also emerged. For example, Baker et al. (2003) reported total accumulated practice hours ranging from just over 2,200 up to nearly 6,000 for basketball, netball, and field hockey players prior to reaching their respective national teams. Similar findings include the duration of the acquisition period, age at which practice commenced, and accumulated hours of preparation time. In addition, participants in both music and sport studies have rated practice activities most closely matching actual domain performance demands as the most relevant aspects of practice.

Differences between the results found in the domains of music and sport have been related to the way activities are perceived and rated. Specifically, research in the sport domain has not supported Ericsson et al.'s (1993) contention that all deliberate practice activities would be rated high on relevance and effort, but low on inherent enjoyment. For example, in sports such as figure skating, wrestling, martial arts, soccer, field hockey, and middle distance running some practice activities have been rated as both highly relevant and enjoyable (Hodges and Starkes, 1996; Starkes et al., 1996; Helsen et al., 1998; Hodge and Deakin, 1998; Young and Salmela, 2002). Research in the sport domain has also found that participants rate concentration or cognitive effort as distinct from physical effort (e.g., Starkes et al., 1996; Helsen et al., 1998). The divergent findings regarding enjoyment of deliberate

practice activities has led some researchers in the sport domain to question if the original deliberate practice framework provides an adequate general description of expertise across domains (e.g., Starkes et al., 1996; Cote, 1999; Macnamara et al., 2016). Hodge and Deakin (1998) noted that "a working definition of deliberate practice has not been realized" and "the framework is in need of revisions if it is to transfer across domains" (p. 277). In response to these observations, work in the sport domain has expanded the original deliberate practice framework to acknowledge that some practice activities can be both highly relevant and enjoyable (Young and Salmela, 2002).

Ericsson et al.'s (1993) deliberate practice framework has been characterized as consistent with the notion that anyone can become an expert by participating in an appropriate amount of deliberate practice (Janelle and Hillman, 2003; Issurin, 2017). Indeed, there are several impressive examples of individuals with disabilities winning Olympic gold medals (Jokl, 1964). Ericsson et al. (1993) suggested that the general nature of the effects of accumulated deliberate practice make it possible for a person with a disability to attain high levels of performance with sufficient practice. They further suggested that the generality of their deliberate practice framework would be supported by research demonstrating practice-driven improvements in performance regardless of the presence of a disability. In short, Ericsson et al. (1993, p. 398) stated that, "...training can compensate for disabilities". At this point in time, however, little research has been devoted to understanding how the experiences of disability-sport athletes align with the deliberate practice framework. After the initial work examining athletes' ratings of practice activities, researchers began to focus more on issues related to early specialization and accumulated hours of deliberate practices as factors to distinguish experts from non-experts (Tedesqui et al., 2019). There is, therefore, a need to further examine how well the defining characteristics of the framework align with the experiences of a broader range of sports, including disability sports.

Given Ericsson et al. (1993) claim and the use of individual examples of athletes with disabilities winning Olympic gold medals to support the purported generalizability of the deliberate practice framework, it is somewhat surprising that so little research has been devoted to the relatively large number of individuals with disabilities who regularly participate in high levels of disability sport competitions. If the deliberate practice framework generalizes to the extent that specific training can compensate for a disability in venues such as the Olympics, then it also follows that the framework should describe the characteristics of expert athletes who participate in disability sport competitions such as the Paralympics. On the other hand, because some of the characteristics of experts within the sport domain differ from those proposed in the original deliberate practice framework (e.g., perceived enjoyment of activities), it is also possible that the characteristics of experts in disability sport will differ from those of able-bodied experts. Most research on training in the disability sport domain has either provided a broad overview of training (Hedrick et al., 1988; Watanabe et al., 1992) or has focused only on narrowly defined differences (e.g., brain activity in shooters; Kim et al., 2013), so there is still a need to determine the extent to which the deliberate practice framework captures the characteristics and experiences of disability sport athletes competing at the highest levels of competition.

An examination of expert disability sport athletes might also provide additional insight into the roles that constraints play in the development and maintenance of expertise. In addition to the typical constraints that all aspiring expert athletes face, many disabled athletes must also cope with the constraints imposed by their disability. For example, these athletes may need specialized equipment, for both their sport participation and general use. The availability of training centers and qualified coaches is also likely to be reduced for disability sport athletes compared to their able-bodied counterparts, requiring substantially greater travel demands and/or additional costs. Because daily routines related to personal care and transportation may require a substantial amount of time, some disability sport athletes may face a limitation in accumulating hours of deliberate practice. The examination of expert disability sport athletes will provide insight into theoretical issues related to the generalizability of the deliberate practice framework and the needs of an underserved population in pursuing high-level sports participation. Although the theoretical issues are the primary focus of this study, the practical implications are no less important. According to the International Paralympic Committee, sport participation by people with disabilities can help rehabilitate their physical bodies, integrate them into society, teach independence, and serve as a competitive and recreational outlet (The International Paralympic Committee, 2009).

The purpose of this study was to examine expert disability sport athletes to document their experiences and characteristics. Consistent with previous deliberate practice research, the primary focus of this study was on accumulated hours of deliberate practice and athlete ratings of relevance, effort, concentration, and enjoyment for selected practice and daily life activities. Two research questions were addressed. The first related to how well the deliberate practice framework accurately described the accumulated hours of domain-specific practice for expert disability sport athletes. This study documented the accumulated hours of practice for national and international level quad rugby players to see how closely their practice experiences matched the so-called "10 year rule." Quad rugby provided a convenient discipline for an initial examination of the deliberate practice framework as it relates to disability sport because it has a national governing body and affords competitive opportunities at national and international levels. Quad rugby athletes therefore fit the framework's focus on performance at the highest levels. In addition, this study examined whether or not the accumulated amount of practice in quad rugby players was moderated by other factors such as the nature of an athlete's disability, time spent in non-practice activities, and experiences with other sports (both prior to and during their quad rugby career). The second research question addressed whether expert disability sport athletes rated deliberate practice activities high on relevance and effort, but low on inherent enjoyment as observed by Ericsson et al. (1993) or high on all three dimensions as indicated by subsequent research in the sport domain (e.g., Helsen et al., 1998). In keeping with previous sport domain research, participants also

rated activities with respect to the amount of concentration required to distinguish between physical and mental effort (Helsen et al., 1998). This study documented ratings of various practice and non-practice activities that were given by national and international level quad rugby players. Ratings of non-practice activities were included to explore the possibility that constraints unique to disability sport athletes' activities of daily living might influence their participation in and/or their ratings of deliberate practice activities for quad rugby.

MATERIALS AND METHODS

Participants

Participants in this study were nine men and one woman ($N = 10$), all at least 18 years of age, who had a disability but were otherwise apparently healthy. All participants had the ability to give voluntary and informed consent using a university approved consent document. Participants were recruited from a pool of quad rugby players who competed on a team in the United States Quad Rugby Association. At the time of data collection, the team had won several national championships and selected members had competed internationally on the United States National Team. Recruiting was accomplished through personal contact. The study was approved by the University of Tennessee, Knoxville Institutional Review Board. All participants gave voluntary informed consent.

Instrument

This study consisted of a single one-on-one session in which participants were asked to complete a written survey adapted from the one used by Young and Salmela (2002). Accommodations were available for any participants who could not complete the survey as designed (e.g., those with difficulty writing due to their disability). This accommodation was provided by the investigator. Prior to conducting the survey, the coach verified that all potential participants had the cognitive capacity to answer the questions on the survey, although many required help with writing.

Part I of the survey requested biographical information concerning the age when practice was first initiated, the highest level attained in quad rugby, success in competitions, and the nature of the participant's disability. Participants estimated the number of minutes devoted to various practice and life activities during a "typical week" for 2-year intervals since beginning their quad rugby career. Participants were allowed to refer to any personal training logs they brought with them. If participants had competitive experience in other sports, they were asked to provide information for those sports as well.

Part II of the survey required participants to rate various practice and daily life activities on four dimensions related to the deliberate practice framework: relevance to improving quad rugby performance; physical effort required; inherent enjoyment; and concentration (i.e., mental effort) required. Each activity was rated with respect to the four dimensions using a scale of 0 to 10, with 0 being low and 10 being high. When rating activities for relevance participants were instructed that a 0 implied no relevance and a 10 meant the activity was the most relevant for improving quad rugby performance. For effort, a 0 implied no effort and a 10 meant extremely effortful. For enjoyment, a 0 implied the activity was not at all enjoyable and a 10 meant the activity was very enjoyable. For concentration, 10 implied that the activity required no concentration and a 10 implied very high levels of concentration. Activities were separated into four categories: individual practice activities, team practice activities, other quad rugby related activities, and daily life activities as seen in **Table 1**. Definitions for all activities were available to participants as they completed their ratings.

Procedures

The investigator had previously met the members of the team after contacting the coach and visiting the practice facility. During this visit, the investigator introduced herself, spoke individually with several team members, presented a broad overview of the proposed research study, and discussed logistical issues with the coach. For recruiting purposes, the coach provided the investigator with contact information for those team members who expressed interest in participating in the study. During initial contact with potential participants, whether in-person or via phone or electronic mail, the investigator scheduled a time to meet in-person to administer the informed consent and survey. During initial contact, potential participants were given a brief description of the study using the information on the informed consent form and were asked to bring training logs to the meeting if they had them.

During the survey administration meeting, all participants provided voluntary informed consent prior to beginning the survey. Part I and Part II of the survey were administered during

TABLE 1 | Taxonomy of various activities related to individual practice, team practice, quad rugby related, and daily life.

Individual practice	Team practice	Quad rugby related	Daily life
Cardiovascular	Cardiovascular	Conversing about quad rugby	Active leisure
Flexibility	Flexibility	Coaching quad rugby	Non-active leisure
Game video analysis	Game video analysis	Diet planning	Snacking
Mental training	Mental training	Physiotherapy	Sleeping
Technique	Technique	Reading about quad rugby	Work/study
Weight training	Weight training	Training journal	House duties
Working with a coach	Working with a coach	Watching quad rugby	Transportation
			Body care

the same session in a setting that was mutually agreed upon by both the participant and the investigator. For each part of the survey, verbal and written instructions were provided. The investigator was available throughout the entire administration period and participants had the opportunity to ask questions at any time. Each survey took from 45 to 150 min to complete, depending upon the length of the participant's career and the nature of any accommodations needed.

Data Treatment and Analysis

Part I data were treated consistent with previous deliberate practice research. Biographical information was summarized and accumulated amount of practice was calculated as a function of the number of consecutive years involved in quad rugby (Ericsson et al., 1993; Hodges and Starkes, 1996; Helsen et al., 1998). For each athlete, accumulated practice hours were calculated for each 2-year interval by multiplying their total hours per week by the total number of weeks in each 2-year period adjusted for off-season time (104 weeks minus total number of weeks off in 2-year period). Results for each athlete were used to plot data of accumulated hours of practice by years of participation in 2-year intervals, which were then visually inspected to identify the nature of the relationship between these two factors. In addition, disability information and involvement in other activities were summarized and examined to determine if these factors potentially influenced the plotted relationship between accumulated hours and years of participation.

Part II data was examined consistent with previous research (Ericsson et al., 1993; Hodges and Starkes, 1996; Helsen et al., 1998; Young and Salmela, 2002). Ratings for activities were compared to a grand mean for each of the four dimensions rated (relevance, effort, enjoyment, and concentration). Because not all participants rated every activity, overall means were calculated using only the ratings that each participant provided. Comparisons between the ratings for each activity and the dimension grand means were completed using dependent paired *t*-tests. To protect for Type I error inflation a Bonferroni correction was implemented by dividing the original alpha value or 0.05 by the number of activities rated. This resulted in a corrected alpha level set at ≤ 0.002.

RESULTS

Part I

Biographical Information

The age of quad rugby participants ranged from age 19 to age 40 (M = 31.3 year; SD = 7.3 year). Reported quad rugby classifications, based upon the classification scale established by the United States Quad Rugby Association, were class 1.0 (n = 1); class 2.0 (n = 3); class 2.5 (n = 2); class 3 (n = 2); and class 3.5 (n = 2). Lower classification numbers represent greater disability than higher numbers (Gumbert, 2004). Three participants acquired their disability at birth. One participant acquired their disability before age 10. Three participants acquired their disability between ages 15 and 20 and three participants between age 20 and 25.

The age when participants began quad rugby ranged from 15 to 31 (M = 22.9 year; SD = 4.1 year). The mean age that participants began working with a coach was 23.8 year (SD = 4.2 year) and the mean age that participants became engaged in year-round participation was 23.0 year (SD = 4.1 year). The mean number of years that participants had engaged in quad rugby ranged from 1 to 18 year (M = 8.5 year; SD = 6.6 year).

Each participant's highest level of competition ranged from national level to the international level. All participants were currently training for the national level tournament through the United States Quad Rugby Association. National level was the highest level of competition for six participants, one participant had competed at the international club level, and three participants had competed in the Paralympics.

Half of the participants had been involved competitively in another disability sport prior to or during training for quad rugby. The competitive levels attained in secondary disability sports included: Paralympic swimming and Paralympic track and field event, World Championships in wheelchair racing, U.S. Nationals in track and field event, and Division II college wheelchair basketball. One participant was involved in able-bodied sport at the Division II college level before participating in quad rugby. The other participants had been involved only in the sport of quad rugby.

Retrospective Estimates of Time Spent in Practice, Quad Rugby Related, and Daily Life Activities

Tables 2, **3** show the descriptive statistics for weekly hours of participation in each of the practice and daily life activities included in the survey. **Figure 1** shows the mean hours per week spent in individual and team practice as a function of the number of years into the participants' quad rugby careers.

TABLE 2 | Mean hours per week for activities related to individual and team practice.

Activity	*N*	*Min*	*Max*	*M*	*SD*
Individual practice					
Cardiovascular training	10	1.00	9.88	4.28	2.99
Weights	10	0.93	5.75	2.55	1.66
Work with coach	4	0.73	5.82	2.35	2.34
Mental preparation	3	0.83	1.50	1.24	0.36
Technique	5	0.30	1.63	1.16	0.51
Flexibility	8	0.22	1.63	0.84	0.53
Game video analysis	3	0.50	1.00	0.67	0.29
Team practice					
Work with coach	10	3.08	11.55	6.37	2.82
Cardiovascular training	10	2.00	10.67	4.57	3.45
Weights	3	1.50	2.00	1.83	0.29
Technique	10	0.25	2.92	1.32	0.77
Mental preparation	7	0.50	2.00	1.21	0.61
Game video analysis	3	1.00	1.40	1.13	0.23
Flexibility	10	0.17	1.47	0.59	0.42

Data are listed in descending order of mean number of hours per week in each activity category.

TABLE 3 | Mean hours per week for activities related to quad rugby and daily life.

Activity	*N*	*Min*	*Max*	*M*	*SD*
Quad rugby related					
Reading about QR	4	1.00	1.83	1.35	0.42
Physiotherapy	8	0.25	1.50	0.94	0.40
Conversing about QR	9	0.03	2.00	0.93	0.58
Organization/preparation	8	0.08	2.25	0.93	0.70
Training journal	3	0.67	1.17	0.92	0.25
Watching QR	5	0.50	1.00	0.85	0.22
Coaching QR	1	0.80	0.80	0.80	0.00
Diet planning	7	0.07	2.42	0.73	0.83
Daily life					
Sleep/study	10	44.10	78.55	58.64	11.21
Transportation	10	3.33	160.00	22.71	48.37
Non-active leisure	10	1.00	37.33	14.99	11.43
Snacking	10	1.07	63.00	12.46	18.05
Household duties	9	0.33	21.00	5.87	6.16
Body care	10	1.30	11.67	5.86	3.33
Active leisure	6	0.25	7.00	2.36	2.49

Data are listed in descending order of mean number of hours per week in each activity category; QR = quad rugby.

For individual practice activities, all participants engaged in cardiovascular training and weight training, and the majority participated in flexibility training. Five or fewer participants engaged in work with a coach, mental preparation, technique work, and game video analysis. The greatest amount of time was spent in cardiovascular training and the least amount of time was spent in game video analysis. Individual practice comprised 6% of the total time participants devoted to the activity categories represented in the survey. An average of about 5 h per week was devoted to individual practice activities at the start of the career. This amount increased steadily to a peak of about 12 h per week at 11–12 years into the career. After that, the average amount of time decreased dramatically. Because of different career lengths, the number of participants reporting decreased as career length increased.

For team practice activities, all participants engaged in work with a coach, cardiovascular training, technique work, and flexibility training. The majority also engaged in mental training. Only three participants engaged in weight training and game video analysis. The greatest amount of time was spent in work with a coach and the least amount of time was spent in flexibility training. Team practice comprised 12% of the total time participants devoted to the activity categories represented in the survey. **Figure 2** shows the mean hours per week spent in team and individual practice as a function of the number of years into the participants' quad rugby careers. An average of about 9 h per week was devoted to team practice activities at the start of the career. This amount increased steadily to a peak of about 14 h per week at 13–14 years into the career. After

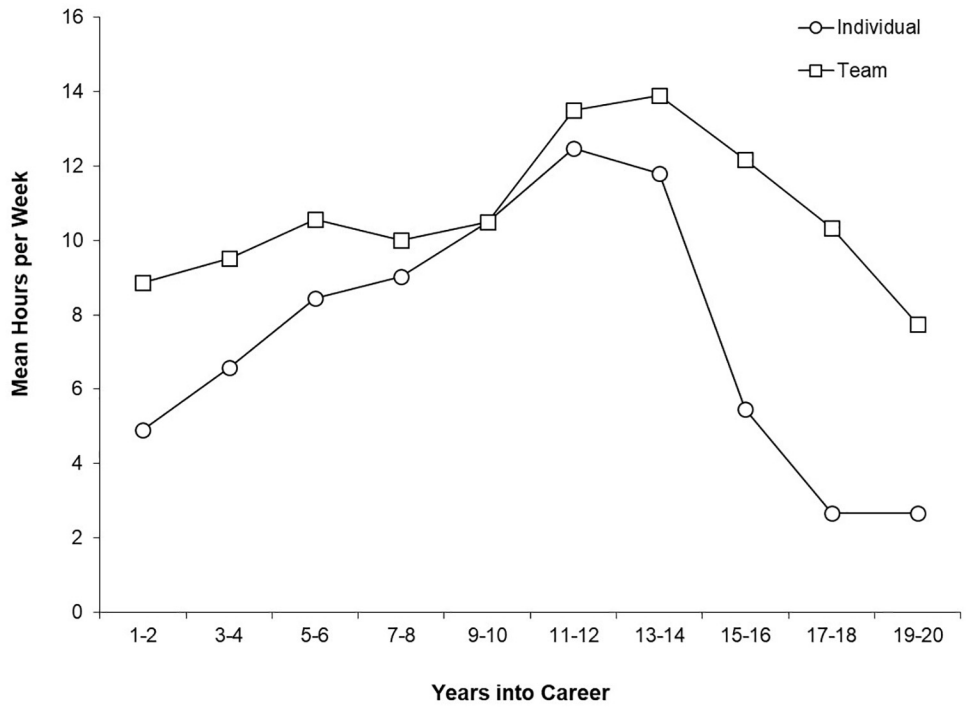

FIGURE 1 | Mean hours per week spent in individual and team practice activities as a function of the number of years into quad rugby career. Hours per week values were based on 10 athletes for Years 1–2; nine athletes for Years 3–4 and Years 5–6; six athletes for Years 7–8; four athletes for Years 9–10, Years 11–12, Years 12–13, Years 13–14, and Years 14–15; and two athletes for Years 17–18 and Years 19–20. The team practice values for two participants in the Years 9–10 and Years 11–12 periods as well as the value for one participant in the Years 13–14 period were excluded because they included hours spent in training camps which did not reflect a "typical week."

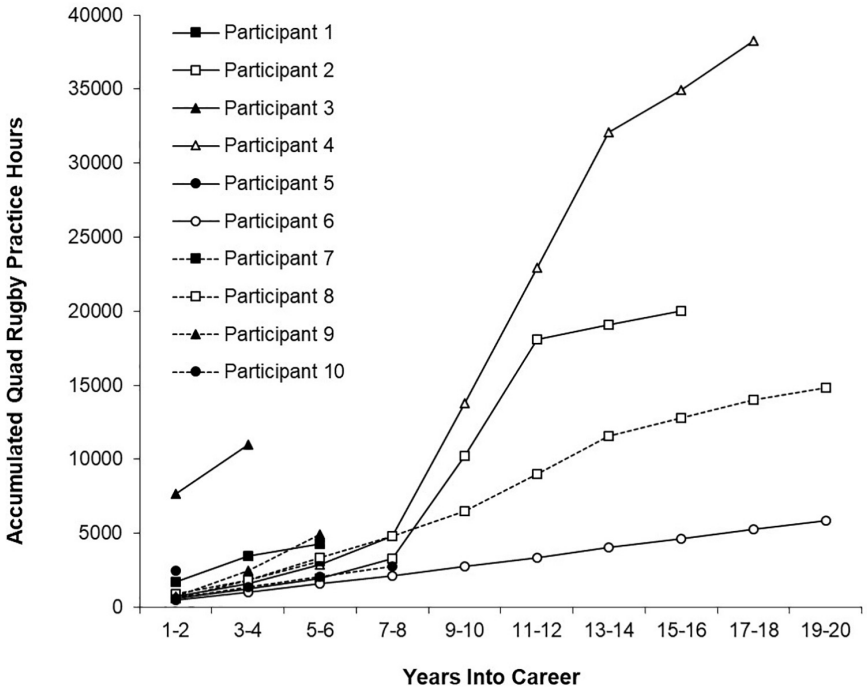

FIGURE 2 | Accumulated hours of practice as a function of the number of years into quad rugby career.

that, the average amount of time decreased dramatically. Because of different career lengths, the number of participants reporting decreased as career length increased. None of the participants with careers that extended past the 13–14 year point reported additional increases in either individual or team activities beyond that time. Reported weekly time spent in practice activities varied greatly across participants. For the beginning of their careers, reports ranged from 0 to 14 h/week for individual practice activities and from 6 to 16 h/week for team practice activities. By the 13–14 year point, reports ranged from 3 to 27 h/week for individual activities and from 5 to 18 h for team activities.

For quad rugby related activities, a majority of participants engaged in physiotherapy, conversing about quad rugby, organization/preparation, and diet planning. Five or fewer participants engaged in watching quad rugby, reading about quad rugby, and training journals. Only one participant had engaged in coaching quad rugby. The greatest amount of time was spent in reading about quad rugby and the least amount of time was spent in diet planning. Quad rugby related activities comprised 3% of the total time participants devoted to the activity categories represented in the survey. None of the participants engaged in all of the quad rugby related activities.

For daily life activities, all participants engaged in sleep/study, transportation, non-active leisure, snacking, and body care. A majority engaged in household duties and active leisure. The greatest amount of time was spent in sleep and study and the least amount of time was spent in active leisure. Daily life activities comprised 79% of the total time participants devoted to the activity categories represented in the survey.

Figure 2 shows mean accumulated hours of practice in 2-year periods for each participant's quad rugby careers. At the start of their careers (i.e., the first 2-year period), participants had accumulated from 513 to 1741 h. The four participants that reported for the 9–10 year period had accumulated from 2,744 to 13,768 h, which equated to a yearly average across the 10 years that ranged from 137 to 688 h/year.

Participation in secondary disability sports during their quad rugby career was reported by five participants. Time in secondary disability sport practice at beginning of quad rugby career (M = 938 h/year) generally decreased throughout the career (M = 600 h/year at 12 year into career), while time in quad rugby practice generally increased.

Part II

Tables 4–7 display the means and grand means for individual and team practice activities, quad rugby related activities, and daily life activities related to the dimensions of relevance, effort, enjoyment, and concentration.

For individual practice activities, the means in the relevance dimension were significantly higher than the corresponding grand means for three practice activities – cardiovascular training, $t(9) = 12.39$, $p < 0.001$, technique work, $t(9) = 8.68$, $p < 0.001$, and work with a coach, $t(7) = 6.47$, $p < 0.001$. Means in the effort dimension were also higher than corresponding grand means for two activities – cardiovascular training, $t(9) = 6.99$, $p < 0.001$, and technique work, $t(9) = 6.80$, $p < 0.001$. The mean in the concentration dimension was significantly lower than the corresponding grand mean for flexibility, $t(9) = -4.62$, $p = 0.001$. In contrast, the mean in concentration for work with coach

TABLE 4 | Ratings for individual practice activities.

Individual	*N*	Relevance	Effort	Enjoyment	Concentration
		M (GM)	*M (GM)*	*M (GM)*	*M (GM)*
Cardiovascular	10	10.00* (7.65)	9.40* (6.00)	5.00 (6.23)	7.10 (5.86)
Flexibility	10	7.40 (7.65)	4.10 (6.00)	4.60 (6.23)	3.00* (5.86)
Game analysis	6	6.33 (7.62)	4.86 (6.63)	4.43 (6.56)	7.00 (6.41)
Mental preparation	7	8.57 (7.69)	5.29 (6.63)	7.29 (6.56)	9.57* (6.41)
Technique	10	9.50* (7.65)	8.60* (6.00)	7.30 (6.23)	8.70* (5.86)
Weights	10	8.50 (7.65)	8.60 (6.00)	6.10 (6.23)	6.60 (5.86)
Work with coach	8	9.36* (7.66)	6.38 (6.09)	6.75 (6.13)	8.88* (5.95)

*0 = low; 10 = high; GM = grand mean. N = number of responding participants for each pair wise comparison. *p ≤ 0.002.*

TABLE 5 | Ratings for team practice activities.

Team practice	*N*	Relevance	Effort	Enjoyment	Concentration
		M (GM)	*M (GM)*	*M (GM)*	*M (GM)*
Cardiovascular	10	10.00* (7.65)	9.00* (6.00)	6.20 (6.23)	7.20 (5.86)
Flexibility	9	7.33 (7.60)	4.67 (5.85)	4.67 (6.20)	3.22* (5.85)
Game analysis	4	7.50 (7.75)	5.75 (7.15)	6.50 (7.17)	7.25 (7.08)
Mental preparation	6	7.17 (7.48)	4.67 (6.56)	5.17 (6.79)	7.50 (6.53)
Technique	10	9.10* (7.65)	7.90* (6.00)	6.40 (6.23)	8.00 (5.86)
Weights	4	8.00 (7.67)	8.75 (6.38)	6.25 (6.92)	7.25 (6.47)
Work with coach	10	9.80* (7.65)	6.40 (6.00)	7.70 (6.23)	8.90* (5.86)

*0 = low; 10 = high; GM = grand mean. N = number of responding participants for each pair wise comparison. *p ≤ 0.002.*

TABLE 6 | Ratings for quad rugby related activities.

Quad rugby related	*N*	Relevance	Effort	Enjoyment	Concentration
		M (GM)	*M (GM)*	*M (GM)*	*M (GM)*
Conversing about QR	10	7.30 (7.65)	5.80 (6.00)	6.70 (6.23)	5.70 (5.86)
Coaching QR	3	9.33 (7.67)	8.33 (6.78)	9.00 (6.97)	9.33 (6.95)
Diet planning	8	8.13 (7.52)	8.25 (6.38)	5.00 (6.44)	7.63 (6.22)
Physiotherapy	4	6.75 (7.53)	6.00 (6.27)	8.50 (6.44)	3.25 (6.33)
Reading QR material	4	5.75 (7.76)	5.25 (7.02)	6.50 (7.04)	5.00 (6.65)
Training journal	3	8.33 (7.81)	7.00 (7.06)	7.67 (7.27)	6.67 (6.90)
Organization/preparation	7	8.71 (7.70)	7.29 (6.07)	5.43 (6.40)	6.14 (5.83)
Watching QR	5	9.20 (7.94)	7.40 (6.71)	6.80 (6.65)	7.00 (6.38)

*0 = low; 10 = high; GM = grand mean. N = number of responding participants for each pair wise comparison; QR = quad rugby. *p ≤ 0.002.*

was significantly higher than the corresponding grand mean, $t(7) = 7.07$, $p < 0.001$. Differences between means and grand means in concentration approached significance for mental preparation, $t(6) = 5.5$, $p = 0.002$, and technique, $t(9) = 4.49$, $p = 0.002$. Enjoyment ratings for individual practice activities were not significantly different from their corresponding grand means (all p-values > 0.013).

For team practice activities, the means in the relevance dimension were significantly higher than corresponding grand means for cardiovascular training, $t(9) = 12.39$, $p < 0.001$, technique work, $t(9) = 4.89$, $p = 0.001$, and work with a coach, $t(9) = 14.21$, $p < 0.001$. Means in effort were significantly higher than corresponding grand means for cardiovascular training, $t(9) = 7.75$, $p < 0.001$, and technique work, $t(9) = 4.62$, $p = 0.001$. The mean in concentration was significantly lower than the corresponding grand mean for flexibility, $t(8) = -4.89$, $p = 0.001$. In contrast, the mean in concentration for work with coach was significantly higher than the corresponding grand mean, $t(9) = 10.38$, $p < 0.001$. The difference between the mean and grand mean in concentration approached significance for technique, $t(9) = 3.93$, $p = 0.003$. Enjoyment ratings for team practice activities were not significantly different from their corresponding grand means (all p-values > 0.023).

TABLE 7 | Ratings for daily life activities.

Daily Life	*N*	Relevance	Effort	Enjoyment	Concentration
		M (GM)	*M (GM)*	*M (GM)*	*M (GM)*
Active leisure	9	6.33 (7.65)	5.22 (5.84)	8.22 (6.16)	4.44 (5.66)
Non-active leisure	10	3.80 (7.65)	2.60 (6.00)	9.30* (6.23)	1.90* (5.86)
Snacking	10	7.60 (7.65)	4.70 (6.00)	8.20 (6.23)	3.40 (5.86)
Sleeping	10	8.80 (7.65)	3.70 (6.00)	9.40* (6.23)	4.10 (5.86)
Work	9	6.78 (7.79)	6.56 (6.15)	4.89 (6.31)	6.67 (5.97)
Household duties	9	1.67* (7.64)	4.56 (6.28)	3.89 (6.29)	3.78 (6.12)
Transportation	10	5.20 (7.65)	4.50 (6.00)	4.40 (6.23)	5.10 (5.86)
Body care	10	7.70 (7.65)	5.90 (6.00)	5.10 (6.23)	5.10 ((5.86)

*0 = low; 10 = high; GM = grand mean. N = number of responding participants for each pair wise comparison; QR = quad rugby. *p ≤ 0.002.*

For quad rugby related activities, ratings of relevance, effort, concentration, and enjoyment were not significantly different from the corresponding grand means (all p-values > 0.006).

For daily life activities, the mean in the relevance dimension was significantly lower than the corresponding grand mean for household duties, $t(8) = -7.29$, $p = 0.001$. The means in enjoyment were significantly higher than the corresponding grand means for non-active leisure, $t(9) = 6.39$, $p < 0.001$, and sleeping, $t(9) = 6.32$, $p < 0.001$. The mean in concentration was significantly lower than the corresponding grand mean for non-active leisure, $t(9) = -5.92$, $p < 0.001$. All other comparisons were not significant.

DISCUSSION

The first purpose of this study was to examine how well the deliberate practice framework accurately described the accumulated hours of domain-specific practice for expert disability sport athletes. Quad rugby participants in this study reported a mean of 8,309 h (SD = 4,756 h) of accumulated team and individual practice at 9 to 10 year into their careers. This was consistent with previous findings on accumulated hours necessary for the attainment of superior performance. Quad rugby participants engaged in similar hours at 9 to 10 year into their careers as those reported by Ericsson et al.'s (1993) best violinists at 10 years (M = 6,351 h), Hodges and Starkes' (1996) wrestlers (M = 5,865 h) at 10 years, and Helsen et al.'s (1998) soccer (M = 6,328 h) and field hockey athletes (6,559 h) at 13 years

into their careers. This study found that disability sport athletes were able to participate in similar amounts of training compared to their able-bodied counterparts. In fact, there was no evidence of additional constraints (e.g., increased daily life preparation requirements, reduced availability of practice locations, and reduced availability of equipment) that negatively affected the number of potential hours available for training. This finding seems at odds with the common perception that a physical disability introduces, at the very least, a need for additional time to complete most daily activities, which raises the possibility that participants in this study sacrificed time in other activities that were not included in the survey. Thus, further research is recommended to clarify this issue.

In contrast to previous findings regarding expertise and deliberate practice, quad rugby participants began practicing well into early adulthood, at about 23 years of age. Thus, it was observed that quad rugby participants begin their career dramatically later than musicians and athletes in able-bodied sports. Presumably, age of entry is influenced by variations in the age at which the disability is acquired. Beginning practice ages have been noted at 8 years of age for musicians, 5 years of age for soccer players, and 13 years of age for wrestlers (Ericsson et al., 1993; Hodges and Starkes, 1996; Helsen et al., 1998). The age of entrance results from this study are similar to previous disability sport research by Hedrick et al. (1988) and Watanabe et al. (1992), which found the age of entrance to disability sport to be an adult phenomenon (age of 24 to 26 year). Therefore, this study concurred with an adult phenomenon of entrance age for disability sport participants. Additionally, participants reported beginning quad rugby, working with a coach, and engaging in year-round participation near the same adult age. This finding shows that high-level performance can still be attained with initiation of deliberate practice late in adulthood for disability sport athletes. Despite some differences from previous research, the results were generally consistent with the notion that practice-driven improvements in performance are possible regardless of the presence of a disability (Ericsson et al., 1993). From a practical standpoint, these findings indicate that quad rugby requires an extensive time commitment over a number of years to reach high-level performance despite that later age of entry and so it should be expected that individual career peaks may occur at later ages than those seen in many other similar sports. Presumably, career peaks might also be of shorter duration as athletes begin to experience aging effects.

Quad rugby participants showed an increase in mean practice hours per week from start of career until the time period of 11 to 14 years into career for both individual and team practice. This was followed by a decrease in the mean number of practice hours per week after 14 years in career for individual and team practice. Previous research on soccer and field hockey revealed a steep increase in mean hours per week from 9 to 15 years followed by an asymptote (Helsen et al., 1998). Helsen et al. (1998) found an increase of time in team practice across career and a decrease of time in individual practice which was not observed in the present study. Across their quad rugby careers, half of the participants were engaged in additional hours of practice for secondary disability sports above and beyond their quad rugby commitments. Because time and energy available for participation are key aspects of Ericsson et al.'s (1993) constraints, competitive participation in secondary disability sports may explain why some participants did not report increases in team practice consistent with expectations of the deliberate practice framework.

Team practice was the primary component of deliberate practice activities, accounting for 12% of the time devoted to all surveyed activities each week. Individual practice comprised the smaller proportion, accounting for 6% of the time devoted to surveyed activities. Because quad rugby is a team sport, it may be that specific activities necessary to the sport are most effectively improved in a team training environment. The importance of such practice with others has been discussed in previous research. For example, even in an individual sport such as wrestling, the importance of sparring practice with partners was rated significantly higher than the mean (Hodges and Starkes, 1996). Similarly, research on soccer and field hockey has found that 65% and 53% of practice time was spent in team practice, respectively (Helsen et al., 1998). Although team practice in the current study represented the largest component of deliberate practice, the proportion of overall time was relatively small compared to the findings for soccer and field hockey. Given that all three sports share some tactical similarities, future research is needed to determine if quad rugby coaches should strive to increase the relative amount of time spent in team training. In the present study, the largest amount of time in team practice occurred in cardiovascular training and working with a coach. Technique work and flexibility were engaged in by all participants, but for a smaller quantity of time during team practice. Game video analysis and working with weights as a team were engaged in by the smallest number of participants. Presumably, a sport such as quad rugby would emphasize tactical and skill dimensions during team training. This perspective is at odds, however, with the finding that cardiovascular training comprised the largest portion of time during team training. The present finding may have been idiosyncratic to the team studied or may represent a unique characteristic of disability sport compared to other sports. More research is needed to document the full range of training activities in other quad rugby teams and across other disabled sports to determine which is the case.

The analyses of individual practice activities revealed that the greatest amount of time was spent in cardiovascular training and weights, with all participants engaging in both activities. Half of the participants engaged in technique work individually, revealing that this type of training was accomplished during both team and individual practice. Relatively few participants engaged in individual practice involving game video analysis and mental preparation. Game video analysis and flexibility contributed the least amount of time for both team and individual practice. It is unknown if the relatively low levels of participation in activities such as game video analysis (individually and with the team) and mental preparation were due to limited availability of resources, time, interest, or other possible factors.

The second purpose of this study was to address whether disability sport athletes would rate deliberate practice activities high on relevance and effort, but low on inherent enjoyment

as predicted by Ericsson et al. (1993), or if they would rate these activities as high on all three dimensions as indicated by subsequent research in the sport domain (e.g., Helsen et al., 1998). Similar to previous research, high relevance and high concentration were found for three activities in quad rugby athletes. Individual technique work, working with coach individually, and working with coach in team practice, were all rated high on relevance and concentration. Team technique work was also found to have a high rating for relevance and a (marginally significant) high rating for concentration. This finding was similar to research conducted on musicians (Ericsson et al., 1993), wrestlers (Hodges and Starkes, 1996), and martial arts (Hodge and Deakin, 1998), which found a corresponding relationship between high concentration and high relevance. Previous research has found that activities mirroring the demands of the actual performed activity are rated high in relevance. For quad rugby, ratings of high relevance and high effort were seen in four activities including individual cardiovascular, team cardiovascular, individual technique work, and team technique work. Previous studies have reported ratings of high relevance for practicing alone by musicians (Ericsson et al., 1993), technical and tactical practice by soccer and field hockey players (Helsen et al., 1998), and running by middle distance (Young and Salmela, 2002). In the present study, cardiovascular training and technique work were therefore identified as important components of practice that closely simulate the actual performance demands of competitive quad rugby.

Consistent with previous research, working with a coach was rated high in relevance for both individual and team practice (Ericsson et al., 1993; Hodges and Starkes, 1996; Starkes et al., 1996). Previous disability sport research has not addressed the relevance of a coach from the participant's perspective. In the present study, working with a coach in a team setting also revealed high ratings for concentration as did both team (presumably under the supervision of a coach) and individual technique work. It is possible that the high degree of concentration for team technique work was partly due to participants' efforts to interpret the coach's instructions and feedback. For individual technique work, high concentration may be directed toward self-monitoring efforts. These findings extended current understanding of participant's perception of the coach and supported the notion that interaction with a coach is a relevant and effortful aspect of quad rugby training.

In previous research, high relevance and concentration ratings for working with a coach have been used to indicate that participants can distinguish between the dimensions of (physical) effort and (mental) concentration (e.g., Hodges and Starkes, 1996). The present results supported this idea. Cardiovascular and technique work were rated as high in (physical) effort for individual and team practice while mental preparation was rated high in (mental) concentration.

Consistent with previous research in the sport domain, high ratings for enjoyment were found for the daily life activities of non-active leisure and sleeping (e.g., Helsen et al., 1998; Hodge and Deakin, 1998). In contrast to expectations emerging from the original framework forwarded by Ericsson et al. (1993), the present study did not find any activities that were rated high for relevance and effort but low for enjoyment. In addition, no activities were rated high for relevance and enjoyment as reported in previous research in the able-bodied sport domain. Instead, the present study found none of the activities were rated significantly higher or lower than the grand mean for enjoyment. These neutral ratings for enjoyment raise the question of what motivates disability sport athletes to engage in deliberate practice activities. The International Paralympic Committee (2009) states that disability sport may provide an outlet for social engagement, competition opportunities, and physical rehabilitation. Perhaps one or more of these potential benefits may be what motivates disability sport athletes.

Overall, the findings from this study revealed limitations in both Ericsson et al.'s (1993) deliberate practice framework and the sport modified framework when describing the characteristics and developmental experiences of disability sport athletes. Nevertheless, many of the characteristics described by Ericsson et al.'s (1993) framework were observed in this study, suggesting that it may prove adequate with some revision to account for the present findings that were unique to disability sport (e.g., neutral ratings of enjoyment). Future research that examines the specific constraints and motivations for disability sport athletes and further documents the characteristics associated with their expertise will contribute not only to the theoretical development of the deliberate practice framework, but will also increase critical knowledge that may benefit an underserved population. The present study had a number of limitations given its narrow focus on members of a single team in quad rugby. Although this approach was successful in describing the characteristics and perceptions of a new group of high-level athletes, the findings may be idiosyncratic to the individuals, team, or sport. Future research is needed to expand current understanding of quad rugby and disability sport athletes. Despite the heterogeneity of the sample in some respects, there was a high degree of variation across individual responses. It is uncertain whether differences in some of the measures (e.g., weekly practice hours) were due to differences in disability, expertise level, motivation, or some combination of these factors. The fact that entrance into disability sport is generally an adult phenomenon precludes examinations of early specialization using the approach of the current study. Such examinations will require much larger sample sizes that will allow for identification and sorting by factors such as degree of disability, age of disability, duration of disability prior to entrance into the sport, and age of entrance into the sport. Future research should also continue the search for objective measures to describe the developmental pathways leading to expertise. Retrospective recall has been questioned as a means for obtaining verifiable data (Howard, 2011), but at the present time better alternatives have yet to be widely adopted. For disability sport athletes, self-report approaches might also be vulnerable to more inaccuracy or inconsistency regarding certain topics. For example, some athletes may feel social pressure to under-report the degree to which extra time

devoted to daily activities negatively impacts the time available to pursue training.

DATA AVAILABILITY

The datasets for this manuscript are not publicly available because of requirements by the University of Tennessee, Knoxville Institutional Review Board. Requests to access the datasets should be directed to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the University of Tennessee Institutional Review Board with written informed consent from all subjects. All subjects gave written informed consent. The protocol was approved by the University of Tennessee Institutional Review Board.

AUTHOR CONTRIBUTIONS

RK and JF designed the study, analyzed the data, and wrote the manuscript. RK collected all the data.

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Understanding High Achievement: The Case for Eminence

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The development of the field of sport expertise over the past 20 years has been remarkable, and our understanding of the varying factors affecting athlete development and motor skill acquisition has expanded considerably. Recently, there has been a push toward more sophisticated research designs to continue the advancement of our understanding of sport expertise. Even in a population of performers at the highest levels of performance and competition (e.g., participants in professional sports or those who compete at Olympic Games), there are those with obvious superiority compared to others in the cohort, such as those who win "most valuable player" awards or who are elected to the Hall of Fame. This paper builds a case that athletes who reach this level of achievement possess a more advanced level of skill than those at the elite or expert stage and we refer to this stage of development as "eminence." This paper explores the notion of eminence and provides converging forms of evidence for the division between expertise and eminence. Moreover, it explores the implications of this division for the further examination of skill acquisition across the lifespan.

Keywords: expertise, sport, development, athlete, training

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The expansion of the field of sport expertise over the past 20 years has been remarkable. As a result, our understanding of the varying factors affecting athlete development and motor skill acquisition has developed significantly (see Baker and Farrow, 2015, for a review). For instance, the need for an extensive period of *deliberate practice* (Ericsson et al., 1993) is now established as a basic requirement for the development of expertise, but the concept of deliberate practice is relatively new to the science of human skill acquisition and expertise. Similarly, the current focus on psychological qualities such as grit (Duckworth et al., 2007) and self-regulation (McCardle et al., 2019), perceptual cognitive issues such as the quiet eye (Vickers, 2016) and representative learning designs (Pinder et al., 2011), and environmental factors such as quality of the early developmental environment (Baker et al., 2009) and the role of athletic parents (Wilson et al., 2019) each reflect relatively new developments in this field of research.

Recently, there has been a push toward more sophisticated research designs to continue the advancement of our understanding of sport expertise. For example, there has been an increased focus on longitudinal research (e.g., Elferink-Gemser et al., 2007; Huijgen et al., 2010; Till et al., 2015), an important improvement over evidence from correlational and

qualitative studies. Despite these improvements in study design, Baker et al. (2015) suggested that our understanding of the process of athlete development is limited due to variations in terms used to categorize skill groups (cf. Swann et al., 2014). They proposed a comprehensive taxonomy for categorizing skill levels from beginning stages to most advanced levels. Having clearer delineations between skill levels is important for understanding differences between groups and improving study designs to explore the mechanisms of these differences. Moreover, they (and others) suggested peak levels of performance could be delineated beyond the "expert" level.

Even in a population of performers at the highest levels of performance and competition (e.g., participants in professional sports or those who compete at Olympic Games), there are those with obvious superiority compared to others in the cohort. For example, Collins et al. (2016) highlighted the differences between those with *multiple* Olympic medals or international "caps" (superchamps) and those with *single* medals wins (champs) and those players who had achieved well at youth levels but did not achieve the same high standard in adulthood. Similarly, Hardy et al. (2017) recently examined differences between athletes who had won multiple medals at the Olympics and World Championships (super-elites) and those who attended these events but did not win a medal (elites; see also Barth et al., 2018). This paper builds a case that athletes who reach this level of achievement possess a more advanced level of skill than those at the elite or expert stage and we refer to this stage of development as "eminence" (see Baker et al., 2015). The Oxford English Dictionary defines eminence as "acknowledged superiority within a particular sphere" which seems an appropriate description for this concept. This paper explores the notion of eminence in North American professional sports, a unique sporting context where success can be measured using a range of performance, attainment, and fame-related variables. With this in mind, we provide several converging forms of evidence for eminence in this population. While the world of professional sport is distinct from other forms of sport, we also explore the implications of this division for the further examination of skill acquisition in sport generally.

INDICATOR 1: MOST VALUABLE PLAYER AWARDS

Among the population of competitors who play professional sports and arguably represent the highest levels of performance in these sports, there is clear distinction between the top players and those at "average" levels of performance. For instance, each year professional sports choose "most valuable player" (MVP) award winners (e.g., the European Golden Shoe in European professional soccer and the Hart Memorial Trophy in the National Hockey League). In this section, we use readily available public access data to describe the proportion of athletes who obtain these achievements in the four major professional sports in North America; the National Basketball Association (NBA), the National Hockey League (NHL), the National Football League (NFL), and Major League Baseball (MLB)[1].

As the name suggests, MVP awards are given to the player who has made the greatest overall impact in a game, series, or season. Similarly, many leagues have position-specific awards (e.g., in the NHL the Vezina trophy is awarded to the top goaltender and James Norris trophy is awarded to the top defense player). The seasonal awards are typically the result of some system of voting. For instance, the Hart Memorial Trophy in the NHL is given to the player voted most deserving by the Professional Hockey Writers Association. Similarly, the MVP award for MLB is voted on by the Baseball Writers Association of America, and in the NBA, the Maurice Podoloff Trophy is currently assigned based on votes from sportswriters and broadcasters, although until 1980 it was determined by NBA players. There are several sportswriter associations voting on MVP awards in the NFL (e.g., the Professional Football Writers Association, Newspaper Enterprise Association, and Sporting News) although the most notable is arguably the Associated Press Player of the Year Award.

The proportion of athletes who obtained an MVP award depends on the league and the current size of the population of players in that league. In the NHL, for example, there were 793 active players in the 2016–17 season of which only one will be named MVP (odds 1 in 793). Odds in the NBA, MLB, and NFL for seasons starting in 2016 ranged from 1 in 388 in the NBA and 1 in 750 in MLB[2] to 1 in 1,696 in the NFL.[3] Obviously, the odds of obtaining position-specific awards are better (e.g., simple odds of winning the Vezina trophy for goaltending in the NHL are 1 in 31) but these values highlight the division between the minority who win major awards and the majority who do not.

Caveat of the "MVP" Indicator for Eminence

While it would seem that the selection of MVP in a given season would be objective and uncontroversial, there is some evidence that this is not always the case. For example, in 1997, during the period when Michael Jordan was considered by many to be the most dominant player in the NBA, he did not win the MVP despite having led the Chicago Bulls to 69 wins that season, tied for the second most of all-time at that point. The award went to Karl Malone in (arguably) one of the most controversial selections in NBA history. Many felt that because Jordan had won the award on four previous

[1]Data were drawn from hockeydb.com, basketball-reference.com, baseball-reference.com, and pro-football-reference.com. Note: All data presented in this article are from secondary, publicly available databases and institutional ethics approval was not required.

[2]In MLB, there is a 25 player "active roster" and a 40 player "expanded roster" that includes all players in the development system eligible for play throughout the season. Although the expanded roster is technically eligible for the MVP award, we have used the smaller active roster in our calculations.

[3]Active players were determined by multiplying allowable roster size by number of teams. All data from Wikipedia.org.

occasions, it was time to give it to someone else (Schoenfield, n.d.). Nevertheless, this MVP selection bias does not appear to be a regular occurrence as there is a discernible standout performer in most seasons. This example also highlights the complex nature of MVP awards and recurring debates that surround them. Namely, it is reasonable to debate whether or not Karl Malone was indeed *more valuable* to his team than Michael Jordan (often such debates focus on the strength of a prospective MVP's teammates). Regardless of whether a "bias" existed in awarding Karl Malone the MVP, Karl Malone is still objectively one of the greatest players in NBA history (indeed, he is a two-time MVP winner). As such, even when controversy exists in the awarding of MVP awards, the debate seems to be *between* eminent athletes.

INDICATOR 2: THE HALL OF FAME

Sports "Halls of Fame" serve to honor athletes (and others such as managers, writers, etc.) who have made lasting contributions to a sport. In the major professional sports in North America explored above, the eligibility criteria for players to be "elected" to the Hall of Fame vary but involve (1) a minimum length of time since retirement (e.g., 3 years for the NHL and NBA, 5 years for living players from MLB and NFL, although MLB limits this to 6 months if the player is deceased) and (2) election by a selection committee normally made up of media members and/or previous Hall of Fame inductees. Our data on the NBA, NHL, NFL, and MLB indicate a considerably smaller proportion of professional athletes obtain this level of achievement (see **Table 1**). To illustrate, in MLB, for example, less than 2% of players who have ever played in the league have attained Hall of Fame status. This is echoed in the other professional sports, where the proportion of the overall population that gains Hall of Fame status ranges from approximately 1–4%.

Caveat of the "Hall of Fame" Indicator for Eminence

To many, election to the Hall of Fame reflects the ultimate recognition of sustained achievement in these sports. However, this indicator is open to bias from the subjective political and moral opinions of those making the election decisions. For example, MLB has maintained a "permanently ineligible" list since 1920 that includes players generally found to have conspired to influence the outcomes of games for their own benefit. Perhaps the best known of these is Pete Rose, undoubtedly one of the greatest baseball players of all time (e.g., winner of three World Series, 17 All-Star Game appearances in five different positions and two "Golden Glove" awards). To date, Rose has been deemed ineligible due to evidence he bet on baseball games for teams he was playing for or managing. There are also some noteworthy players (e.g., Barry Bonds and Roger Clemens) with exceptional performance statistics suspected of using performance enhancing drugs that have to-date been passed over in Hall of Fame voting. All this to say, there is a level of subjectivity to whom eventually makes it to the Hall of Fame in some sports.

INDICATOR 3: CAREER LENGTH

Successful athletes need to continually adapt to changes in the competition environment and manage age- or injury-related declines that might negatively impact their performance. The high performance sport environment is the ultimate Darwinian "survival of the fittest" system and any athlete who is unable to adapt to these changes is (often rapidly) removed from the system. For example, athletes who relied more heavily on physical performance advantages (e.g., speed and strength) early in their career may have to adjust their game later in their career, perhaps learning new skills or relying more heavily on acquired perceptual-cognitive skills.

Arguably, those who are capable of staying in the environment longer (i.e., longer than average) represent a different cohort than the average performers in this population. Below, by way of example, we provide data for all players from the four major professional sports in North America drafted between 1980 and 1989. These dates were chosen because all of these players had completed their playing careers (see Baker et al., 2013, for more on these data). **Table 2** presents

TABLE 1 | Proportion of professional athletes who make their respective sports' Hall of Fame.

Sport	Total *N*[a]	Hall of Fame *N* (%)[b]
Ice Hockey (NHL)	7,596	281 (3.7)
Baseball (MLB)	19,429	261 (1.3)
American Football (NFL)	25,791	279 (1.1)
Basketball (NBA)	4,668	124 (2.7)
Total	57,484	945 (1.6)

Data from official archives for each professional sport (nhl.com; mlb.com; nfl.com; nba.com).
[a]Total number of athletes who played in the respective sports up to the 2018–2019 seasons.
[b]Total number of athletes who were inducted into the respective sports Halls of Fame up to the 2018–2019 eligibility periods.

TABLE 2 | Mean career length for populations of athletes in the NBA, NFL, NHL and MLB.

Career length	NBA	NFL	NHL	MLB
Total				
Mean	8.2	5.5	7.8	7.3
SD	5.4	4.1	5.9	5.3
Bottom 95%				
Mean	7.4	5.0	7.9	6.7
SD	5.0	3.5	5.1	4.6
Top 5%				
Mean	17.9	15.2	20.5	19.5
SD	1.5	2.2	1.5	1.9

The top 5% of players roughly equates to those whose careers were two standard deviations above the mean career length. Data from Baker et al. (2013).

the average and standard deviations for career lengths among these groups. These data indicate the average career of a professional athlete in these sports during that decade generally ranged between 5.5 years for athletes playing in the NFL and 8.2 years for players in the NBA. However, the standard deviations suggest considerable range around these mean values.

Preferably, players (and teams) want to have as long a career as possible. However, career length in professional sports is highly negatively skewed (see **Figure 1**). If we consider the top 5% of players in these leagues (i.e., those whose career length is two standard deviations from the population mean), we see much longer careers in this group. In MLB, the top 5% of players have an average career length of 19.5 (SD = 1.9); similarly, the top 5% of career lengths in the NBA, NHL, and NFL are 18.0 (SD = 1.4) years, 20.5 (SD = 1.5) years, and 15.2 (SD = 2.2) years, respectively.

Caveat of the "Career Length" Indicator for Eminence

While longer career length indicates important characteristics such as amenability and resiliency for the athlete, this may also mean taking on a different role. More specifically, this indicator of eminence may be confounded by players who have retained a roster spot longer than expected for their ability to maintain team chemistry and morale, for example, rather than their play itself (these players often referred to as "glue guys" or "role players"). Similarly, players who have performed well in prior seasons or who were "marquee" players early in their careers may have longer careers due to "sunk costs" (see Staw and Hoang, 1995). Consequently, considering there is such a small sample of "eminent" players, there is value in triangulating indicators of eminence or considering minute thresholds in order to avoid a distorted understanding.

INDICATOR 4: THE LOTKA-PRICE ASSUMPTION

Another reason for distinguishing a layer beyond "expert" is based in data supporting the Lotka-Price Curve, reflecting a well-known phenomenon about how advancements in various fields occur. For example, examinations of achievement in science have typically supported the conclusion that a relatively small proportion of elites drive progress in a field (e.g., Dennis, 1954; Cole and Cole, 1972; Huber, 1999; Simonton, 1999). Lotka (1926) and Price (1963) hypothesized that scientific progress follows an inverse square law, proposing that the number of scientists publishing n papers is proportional to $1/n2$. This inverse square relationship suggests that for every 100 authors producing a single paper, 25 will produce two papers, 11 with three, and so forth. The Lotka-Price Law also indicates that approximately 50% of the papers published during a given period will be produced by 10% of the actively publishing scientists. In the field of psychology and sport psychology, Simonton (2002) and Baker et al. (2003), respectively, have provided support for the Lotka-Price curve, and this relationship has also been found in a range of performance domains (see Murray, 2003).

There is also evidence of this relationship across a range of sport contexts (see for example Petersen et al., 2008; Den Hartigh et al., 2016, 2018). **Figure 2** below describes the frequency of wins among players who have won grand slam

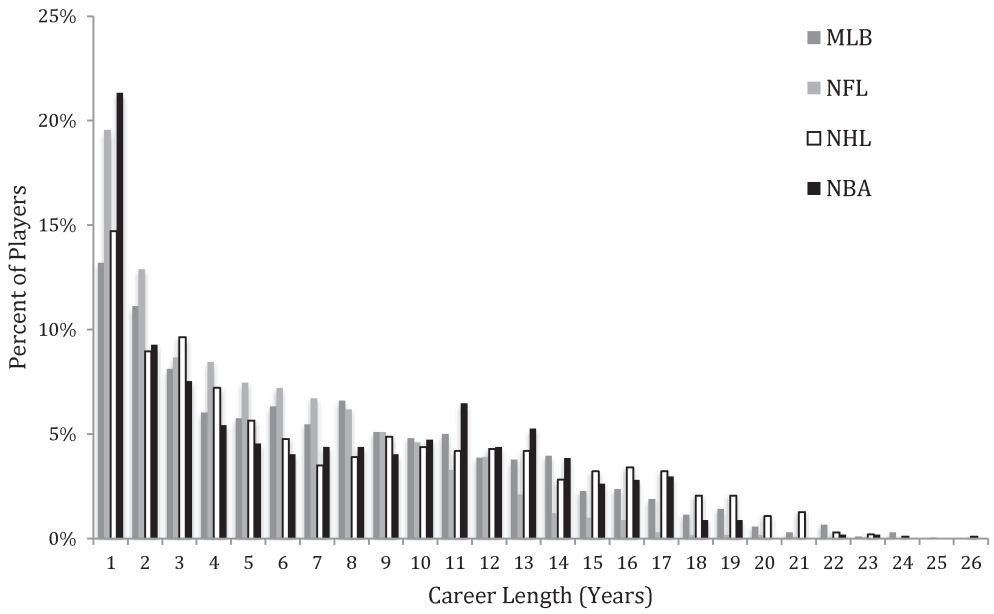

FIGURE 1 | Distribution of career lengths in professional athletes from the NFL, NHL, NBA, and MLB (data current as of end of 2018 seasons).

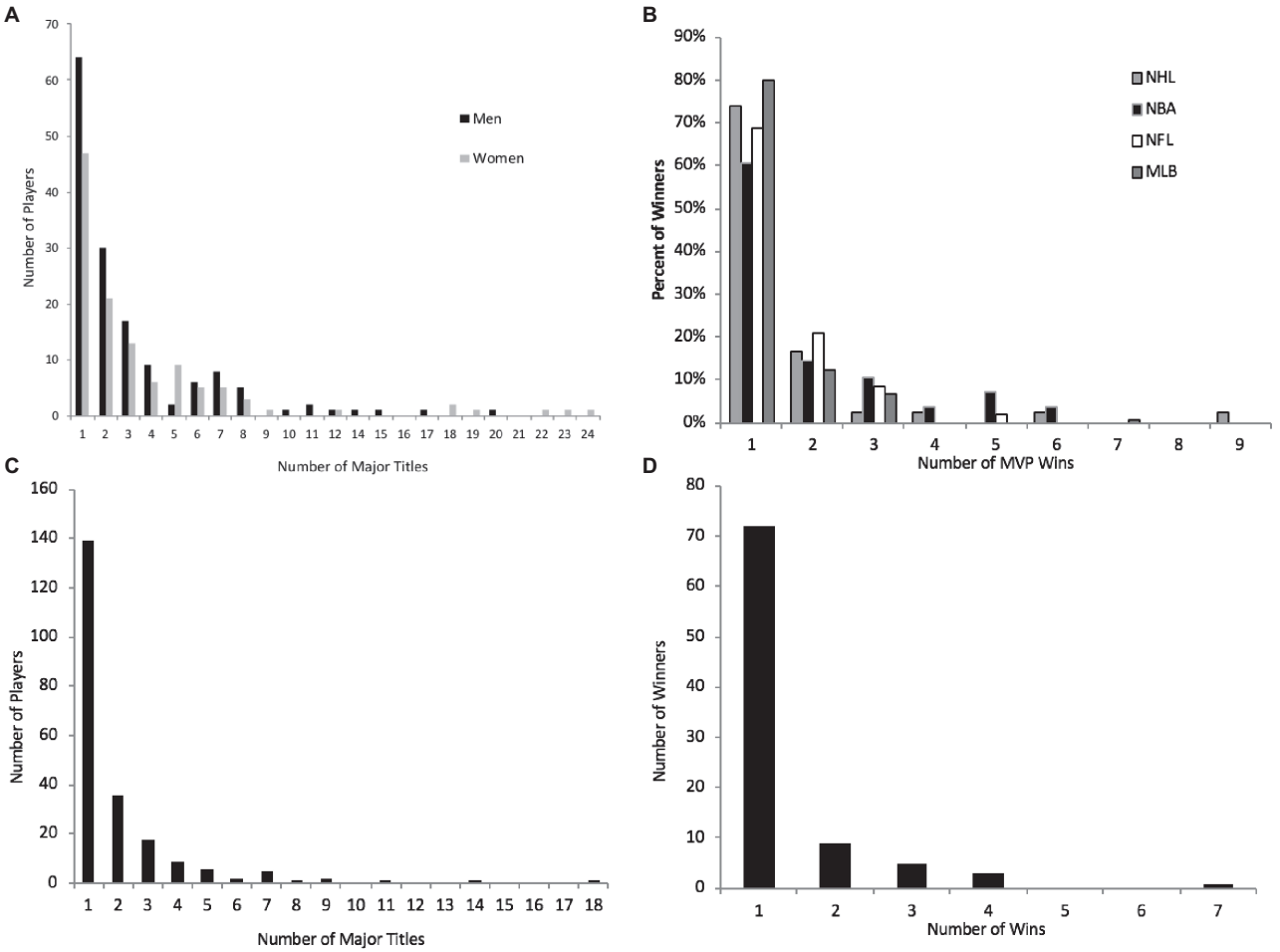

FIGURE 2 | Lotka-Price Curve as demonstrated by **(A)** frequency of wins among players who have won grand slam events in tennis, **(B)** frequency of MVP awards in the NHL, NBA, NFL, and MLB (in %) **(C)** frequency of wins among golfers who have won "major" events on the PGA, and **(D)** frequency of wins among winners of the Boston Marathon (in %).

events in tennis, MVP awards in the NHL, NBA, NFL, and MLB, Professional Golfers' Association (PGA) golfers who have won "major" events, and winners of the Boston Marathon. In each of these cases, performance and achievement follows the Lotka-Price curve (see also Murray, 2003).

Caveat of the "Lotka-Price Assumption" Indicator for Eminence

The Lotka-Price profile reflects a relationship between number of athletes in a population and the proportion of those athletes making major achievements. Determining which athletes were among those making "major achievements" in their field could be somewhat arbitrary since achievement in sport varies (e.g., specific positions will have different objectives c.f. goaltenders versus centre-forwards). Further, using the Lotka-Price criterion as an indicator of eminence requires determining a threshold for categorization (i.e., at what point on the curve does the performance become "eminent"?). The caveats to our eminence indicators listed above highlight the complexity of such categorization.

NEED FOR MULTIPLE INDICATORS

As noted several times above, it would be valuable to establish a set of clear criteria for the identification of an "eminent" athlete in order to overcome some of the limitations of previous work on exceptional performers. Ideally, given the limitations noted for each individual indicator, this would involve some combination of indicators such as those identified above as well as others yet to be identified. This would have the advantage of triangulating data sources to ensure that any designation is based on multiple indicators thereby providing some evidence of convergent validity. In our list of indicators, there are those that are clearly more objective and grounded in performance (i.e., the Lotka-Price and career length indicators) as well as indicators that may be more

subjective and open to social influence (i.e., MVP and Hall of Fame indicators). Using multiple indicators would help reduce the likelihood of any single indicator biasing an athlete's classification. Moreover, having clear, well thought out indicators would reduce the possibility of conflating "fame" with "eminence," the former reflecting a social construction (society signifies who becomes famous) and the latter reflecting, at least in our view, an outcome based on robust performance indicators.

It is important to emphasize that the indicators of eminence discussed above are particularly relevant for these professional sports and, undoubtedly, the indicators will need to be adjusted to the sport and context under examination. For example, in European football, Hall of Fame or MVP is not appropriate; here, appearances in international tournaments, matches or goals as well as Ballon D'Or might be better indicators of eminence. However, it is important to note that this could be difficult to determine statistically for each individual performer due to differences in the time course of an athlete's development. For instance, many athletes in the career length dataset utilized above have not been retired long enough to make it to the Hall of Fame and so the relationship between these indicators in contemporary samples is unknown. Interestingly, every NBA player who has won the MVP award and is eligible for the Hall of Fame has been inducted. It is probable that those at the highest levels of performance as reflected in the Lotka-Price curve will also be those with the longest careers and more likely to achieve Hall of Fame honors. We explore these assumptions below.

CASE STUDY: THE NATIONAL HOCKEY LEAGUE

Now that we have established the case for the eminence level of skill, we examine these indicators in a population of athletes from a single sport to determine the level of agreement between indicators. Our intention in this descriptive analysis is to demonstrate one process by which eminent players could be identified using readily available data.

Description of the Analysis

The NHL has been in existence since 1917 and has grown from the "original six" teams to the current system with 31 teams from across Canada and the United States. Throughout the history of the NHL, there has been considerable change (e.g., teams added, moved, etc.) and therefore historical samples might have limited relevance for current samples. Given that the indicators have different timescales, not all indicators are possible in contemporary samples (e.g., career length is easy to calculate at the end of a player's career, but Hall of Fame status may not be determined until decades after a career ends). In this descriptive analysis, we began with identifying NHL players who won the Hart Trophy, established in 1923 for the "most valuable player to his team" and determined how many met other indicators of eminence (**Table 3**). Moreover, we limited our analysis to players who were active in the pre-1970 NHL. This cut-point, while seemingly arbitrary, reflects an important phase in the history of the league, after the considerable expansion of the league between 1967 and 1970 and is likely a stronger reflection of the current environment. Subsequently, we determined the proportion of players who were also MVPs at some point in their career and were elected to the Hall of Fame. Of the eligible players since 1970 (n = 17) who have won the Hart Trophy, only one has not been elected to the Hall of Fame (i.e., 94% agreement).

TABLE 3 | Summary of eminence indicators in NHL case study sample.

Name	Position	Hall of Fame [a]	Career length [b]	Career points	Lotka-price cutoff [c]
Bobby Orr	Defense	Yes	12	915	Yes
Phil Esposito	Centre	Yes	18	1,590	Yes
Bobby Clarke	Centre	Yes	15	1,210	Yes
Guy Lafleur	Right Wing	Yes	17	1,353	Yes
Bryan Trottier	Centre	Yes	18	1,425	Yes
Wayne Gretzky	Centre	Yes	20	2,857	Yes
Brett Hull	Right Wing	Yes	19	1,391	Yes
Mark Messier	Centre	Yes	25	1887	Yes
Mario Lemieux	Centre	Yes	17	1,723	Yes
Sergei Fedorov	Centre	Yes	20	1,179	Yes
Eric Lindros	Centre	Yes	13	865	No
Dominik Hasek	Goalie	Yes	16	NA [d]	Yes
Chris Pronger	Defense	Yes	16	698	No
Joe Sakic	Centre	Yes	21	1,641	Yes
Jose Theodore	Goalie	No	18	NA [d]	Yes
Peter Forsberg	Centre	Yes	13	885	No
Martin St. Louis	Right Wing	Yes	17	1,033	Yes
Average			17.4	1376.8	
SD			3.2	538.0	
% Agreement		94%			82%

[a] *Player in the Hall of Fame.*
[b] *Career length in years.*
[c] *Did player meet Lotka-Price cutoff of 898 career points.*
[d] *Goalie data not applicable.*

Next, we considered this same group of 17 players on career length relative to the career lengths determined by Baker et al. (2013). In their analyses of NHL players from 1980 to 1989, they found that the average career length was 7.83 years (SD = 5.84 years). In the MVP sample, career length was 17.4 years (SD = 3.2), suggesting a considerably longer career than the average player. Finally, we plotted the Lotka-Price curve for "career points" (including goals and assists) for all skating players (N = 843; goaltenders were eliminated) in the NHL from 1980 to 1989, which was the most contemporary dataset we could use where players were likely to have completed their careers. We then identified a "cutoff" to identify the top 5% of performers on this outcome (i.e., two standard deviations from the mean, 898 career points, see **Figure 3**). If we compare this to the average career points for our sample of MVPs, their average (M = 1376.8) is notably higher than the cutoff used

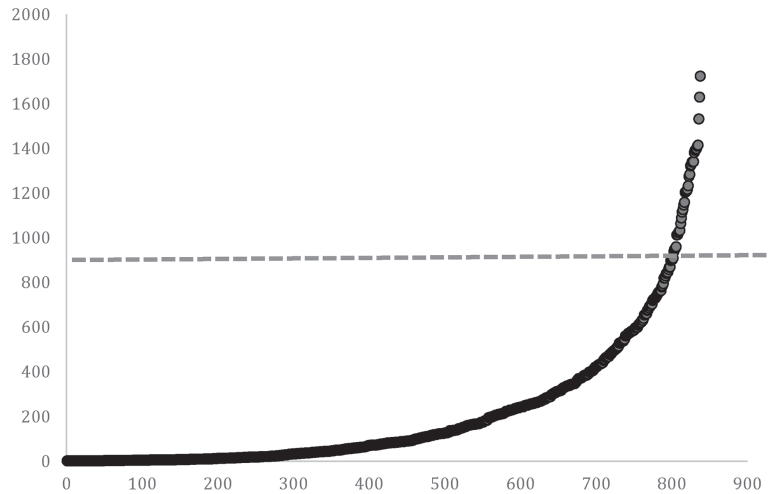

FIGURE 3 | Lotka-Price curve for career points (y-axis) among NHL players drafted between 1980 and 1989 (x-axis). Note: dashed line represents cutoff for top 5% on this outcome.

for our Lotka-Price indicator although there is some variability among the players. All but three of the players met the Lotka-Price assumption, reflecting an agreement of 82%. All in all, this exploratory analysis indicates good consistency between indicators and provides some evidence of convergent validity. However, continued attention to validating these indicators would be important (e.g., how do subjective indicators of eminence change over time such as reflected in "best ever" lists of players, etc.).

THE IMPORTANCE OF THE EMINENCE STAGE FOR UNDERSTANDING ATHLETE DEVELOPMENT

Although this paper argues for a new skill distinction for eminent performers, this view is not without some limitations. First, it assumes these groups can be easily divided into meaningful levels of skill (e.g., intermediate, advanced, expert, and eminent), which runs counter to the notion of skill acquisition as a continuous, on-going process without delineation points reflecting different skill groups. Moreover, it could be easily argued that any population of "eminent" individuals could be further sub-divided into infinitely more detailed categories (e.g., the very eminent).

While these concerns are reasonable, the empirical study of expertise often requires the use of experimental (i.e., between subject) designs that require categorization of individuals into groups for the basis of comparisons. As such, having stricter criteria for accurately grouping individuals is important. Further, study designs in expertise research are still dominated by the expert versus novice/non-expert comparison despite calls for the past 25 years to expand the skill groups being considered (e.g., Abernethy et al., 1993; Baker et al., 2015). Importantly, skill-group classifications need to be justified using multiple indicators. In this paper, we have argued for several indicators relevant for athletes in the major professional sports in North America but the argument holds for other professional and competitive sports, as well as for other levels of skill (i.e., stronger arguments for classifying "novices" or "near elites").

In the sections above, we delineate a stage above the expert level on the basis that this group might be important for advancing our understanding of exceptional attainment. For example, a dominant paradigm in the field of expertise development over the past 25 years has focused on the role of "deliberate practice" in explaining expert achievement. Those who argue against the role of deliberate practice as a sufficient explanation often evoke the names of eminent individuals (e.g., Amadeus Mozart, William Shakespeare, see Feldman and Katzir, 1998) as evidence against the practice account. Their argument is that (1) these individuals are exceedingly rare in any domain and (2) they make achievements that are qualitatively and quantitatively greater than the "average" high-level performer. On the one hand, this argument might simply reflect the obvious variability within a population of expert performers. That is, individuals who have reached the pinnacle of achievement in a domain (e.g., meeting one or more of the criteria discussed above) represent a different group of performers than "average experts" — similar to how experts are distinguishable from near-experts (i.e., those at a level of performance slightly lower than expert). Furthermore, the existence of eminent performers among expert samples may add important, but obfuscated, variation within studies. For example, whether studies measure performance metrics, accumulated practice, or differences in perceptual cognitive skills, it is not well understood how (or if) eminent athletes may act as statistical outliers that have an influence on aggregate group statistics. Determining the validity of this designation has the potential to promote greater understanding of the highest levels of skill development.

An eminent stage of development could also further our knowledge regarding the influence of different predictors/constraints

on the highest levels of achievement. Already, researchers have identified intriguing factors that may differentiate multiple medalists from non-medalists including personality traits such as of selfishness and ruthlessness (see Hardy et al., 2017) and continued examination of this group, and how they differ from "experts" could lead to important insights. It is perhaps important to note that, increasingly, it is this ultimate level of achievement that coaches, athletes, and governments are interested in understanding. For example, the re-structuring of Canada's high performance sport system was designed to "Own the Podium" during Olympic competition, rather than to simply participate, with an emphasis on obtaining top-3 finishes. Exploring this group would also facilitate superior study designs to prevent skill-level variance from "washing out" any differences between skill groups.

Ultimately, identifying those with the highest levels of attainment in a domain will help us better understand the stages of career development as well as the factors affecting this development. Moreover, it may provide us with insight regarding the long-term consequences of involvement at the most extreme level of performance (e.g., effects of extreme training/diet/weight loss, etc.).

CONCLUDING THOUGHTS

The past few years have seen increased emphasis on the need to improve research designs in skill acquisition and expertise research (e.g., Baker et al., 2015; Johnson et al., 2018, see also Abernethy et al., 1993). In the sections above, we justify a distinction at the highest levels of attainment to capture athletes who have achieved "eminent" status and demonstrate how this distinction might be identified in a population of elite athletes. That said, explorations in this new population will come with their own methodological constraints. For instance, the number of eminent athletes is small to begin with, so studies of this type will almost always be limited in sample size. Even in the case study presented above, there were only 17 eminent players in a 34-year period (all players awarded the Hart Trophy after 2005 are still active in the league), which prevents the use of more complex statistical approaches. While it may be attractive to relax the categorizations used to identify the eminent group, it is likely more important to keep the definition strict. Having stronger criteria for identifying and classifying athletes into skill groups will ultimately assist researchers seeking to understand the factors facilitating and impeding long-term development, as well as the mechanisms underpinning truly exceptional sporting achievement.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

All data presented in this article are from secondary, publicly available databases and institutional ethics approval for this analysis was not required as per applicable institutional and national guidelines and regulations.

AUTHOR CONTRIBUTIONS

JB was the primary author and wrote the manuscript with the help and guidance of co-authors. JS contributed to formulate the structure of this project, helped develop the rationale, and edited the manuscript. SL also helped develop the rationale, and edited the manuscript. NW contributed to the development of the manuscript with JB, and co-wrote and edited the manuscript.

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CONCEPTUAL ANALYSIS
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Developing Creativity to Enhance Human Potential in Sport: A Wicked Transdisciplinary Challenge

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The challenge of developing creativity to enhance human potential is conceptualized as a multifaceted *wicked problem* due to the countless interactions between people and environments that constitute human development, athletic skill, and creative moments. To better comprehend the *inter-relatedness* of ecologies and human behaviors, there have been increasing calls for transdisciplinary approaches and holistic ecological models. In this paper we explore an ecological dynamics rationale for creativity, highlighting the conceptual adjacency of key concepts from transdisciplinarity, dynamic systems theory, ecological psychology and social-cognitive psychology. Our aim is to extend the scope of ecological dynamics and contextualize the application of non-linear pedagogy in sport. Foregrounding the role of sociocultural constraints on creative behaviors, we characterize the athlete-environment system as an ecological niche that arises from, and simultaneously co-creates, a *form of life*. We elaborate the notion that creative moments, skill and more generally talent in sport, are not traits possessed by individuals alone, but rather can be conceived as properties of the athlete-environment system shaped by changing constraints. This re-conceptualization supports a pedagogical approach predicated on notions of athletes and sports teams as complex adaptive systems. In such systems, continuous non-linear interactions between system components support the exploration of fluent and flexibly creative performance solutions by athletes and sports teams. The implications for practice suggest that cultivating a constellation of constraints can facilitate adaptive exploration of novel affordances (opportunities/invitation for action), fostering creative moments and supporting creative development in athletes. Future models or frameworks for practice contend that pedagogies should emerge from, and evolve in, interaction with the sociocultural context in which practitioners and athletes are embedded.

Keywords: transdisciplinary research, wicked problems, ecological dynamics, sociocultural constraints, forms of life, non-linear pedagogy, coaching, football

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INTRODUCTION

Historically, the boundaries of human potential (across many domains) have tended to be re-configured by serendipitous situations and creative moments. Moments of creativity have advanced our knowledge, re-shaped our lives, altered our understanding, and challenged the perceived limits of what can, and cannot, be achieved (Songca, 2006; Montuori, 2011; Glăveanu et al., 2019). Fostering creativity and expert performance in sport and physical activity is often predicated on new training paradigms that provide novel performance insights and develop innovative practices. The Fosbury flop is an example that quite literally raised the bar (Orth et al., 2017) and redefined human performance and potential in the high jump event.

The example of the Fosbury flop in sport suggests that non-linear transitions in performance could be supported by contemporary theorizing on teaching and coaching to foster creative development and realize human potential across the lifespan. This paper offers a new point of departure for research aimed at practical applications in sport and physical activity. Initially, we argue that developing creativity is a multifaceted challenge requiring research approaches that incorporate, rather than isolate, interdependencies and interactions between athletes and their environment. Next, we outline the conceptual adjacency of key concepts from transdisciplinarity, dynamic systems theory, ecological psychology and socio-cognitive psychology in order to extend the scope of ecological dynamics, better contextualize the application of non-linear pedagogy and illuminate our view of creativity in sport. Finally, we discuss the role of sociocultural constraints on creativity by undertaking a contextual analysis and offering practical considerations.

More than a mere performative act we conceptualize creativity as a crucial component of human development and recognize its relevance for all sports participants at all levels (Rasmussen et al., 2017). Creativity is not only a point to reach; it is the process or means of reaching for human potential. It is a development resource that inspires further learning, especially in sport (Rasmussen et al., 2017). A majority of creativity research in team sport has focused on a tactical emphasis founded in information processing models of cognition (Furley and Memmert, 2015; Memmert, 2015). However, broadening perspectives are shifting toward a recognition of athlete-environment dynamics (Hristovski et al., 2012) and exploring: the role of early life social interactions (Martin and Cox, 2016), affordances (Glăveanu, 2012; Rasmussen et al., 2017), movement variability adapting to constraints (Orth et al., 2017) and multidisciplinary frameworks of creative development (Santos et al., 2016).

The challenge of developing and enhancing creativity in the modern world is a complex one. Countless interactions between people and places, influence myriad development processes impacting multiple aspects of creativity. In emphasizing the sociocultural basis of understanding creativity, a recent commentary highlighted that the creative process needs to be conceptualized as embodied, multi-dimensional, culturally-mediated, relational, dynamic and situated, amongst other facets (Glăveanu et al., 2019). To better comprehend the *inter-relatedness* of ecological and human sub-systems there have been increasing calls for transdisciplinary approaches (Balagué et al., 2017). We contend that this type of approach could highlight the sociocultural and historical constraints on creative development and demonstrate the pursuit of human potential as a *wicked problem* (Levin et al., 2010).

Wicked Problems and Developing Creativity

Wicked problems are global challenges that often involve many societal groups and social systems, have unpredictable consequences, and do not lend themselves to straightforward, traditional solutions (Rittel and Webber, 1973). To exemplify, consider the multifaceted influence of corporate capitalism, not only is it an economic system that exploits the worlds material environment (Brown et al., 2010), but recent research points to a toxic influence on sociocultural systems as well. Unrestrained advertising has been found to foster harmful social conditions and contexts that are detrimental to psychological development, impacting human potential, particularly during childhood (see Kasser and Linn, 2016). The *wickedness* of interrelated problems is not only about high degrees of complexity, but also represents a recognition that no level of linear (or mono-disciplinary) thinking might present a workable solution. Critically, the wickedness requires a holistic, deeply contextualized understanding of problems and positions solution generation as a secondary concern (Plamer et al., 2007).

Creative problem solving has been called upon to address the world's wicked problems (Songca, 2006; Bocchi et al., 2014). However, cultivating the cultural contexts and social systems that foster human creativity requires that we confront the challenge of developing creativity, a wicked problem in its own right. As a brief example of this wickedness, consider that the dominant "understanding of creativity has been shaped by cultural, methodological, and epistemological factors" (Montuori and Purser, 1997, p. 1) and that the majority of studies of creativity in the literature originate from cultures that orientate strongly toward individualism, and whose scientific approaches have typically been reductionist (Montuori and Purser, 1997; Glăveanu et al., 2019). "If creativity is viewed as *nothing but* a factor of personality, or *nothing but* a factor of cognitive or genetic forces, or, for that matter *nothing but* the product of historical forces, then we are falling victims to a kind of reductionism (whether genetic, psychological, or sociological) that severely restricts and impoverishes our understanding of creativity" (Montuori and Purser, 1997, 14 italics in original). In this paper we aim to cultivate a more holistic understanding of creative development by demonstrating that fostering creativity and human potential, like many of the world's complex and ill-defined challenges, is a *wicked problem* (Levin et al., 2010) in need of transdisciplinary inquiry (Songca, 2006).

The Potential of Transdisciplinary Research

To better comprehend wicked problems and transcend traditional linear thinking in sport, work organization and education there have been increasing calls for transdisciplinary research (Songca, 2006; Bocchi et al., 2014). At present,

transdisciplinary research is flourishing in the field of sustainability science. In over 20 completed, or ongoing projects, transdisciplinary processes lay the foundations for investigations into the complex interactions of socio-ecological systems (see Herrero et al., 2018). In sport, transdisciplinary approaches are scarce. However, a recent study demonstrated potential benefits and revealed the sociocultural forces influencing Australian talent development programs (Toohey et al., 2018). Academics and practitioners across diverse theoretical perspectives came together to investigate four sports—Australian rules football, cricket, kayaking and tennis—and concluded that a complex composition of physical, psychological, environmental and contextual factors shape talent development (Toohey et al., 2018). To capture the complex interactions of these multiple facets to advance theoretical knowledge and improve applied practice, it is vital that sports research transcend mono-disciplinary approaches, and move beyond a "paradigmatic, quantitative (*often reductionist*), sport science lens" (Toohey et al., 2018, 356 italics added).

A sport science lens can be characterized by quantitative, typically reductionist and mono-disciplinary approaches to physiology, motor-learning, biomechanics, and psychology. This lens has shaped applied practices that range from: strength, conditioning and injury rehabilitation; coaching pedagogy; video analysis and much more. The reliance on a positivist lens creates bias toward a one-dimensional, decontextualized and cyclical production of fragmented knowledge (Alhadeff-Jones, 2009). As such, a majority of sport science research and practice has been limited by a history of "organismic asymmetry," foregrounding the "internal mechanics" of the athlete and neglecting relations with the environment (for a detailed argument see Davids and Araújo, 2010). The separation of organism and environment, alongside other decontextualized (and mono-disciplinary) approaches "enormously simplifies the type of integration among organizational levels in living systems" that range "from genes to social systems" (Balagué et al., 2017, p. 2). That is, the *inter-relatedness* of sub-systems makes it challenging to understand (from methodological and theoretical perspectives) how different dimensions of human behavior (e.g., physical, cognitive, psychological, emotional, social, cultural, and historical) continuously interact to influence performance and development (and creative moments) on various timescales (Davids et al., 1994; Balagué et al., 2017). As a result, many practitioners, coaches and sporting organizations educated in the traditional "sport science lens" hold an (ontologically) limited picture of the complexity of sports performance and human development (Mallo, 2015). In practice, the design and assessment of training sessions becomes dominated by statistical analysis of "kilometers run" and "sprints made" (quantitative measures of physical load). This critique is not an assault on disciplinary research, or a call for sports science to abandon performance measurement and evaluation entirely. However, it spotlights the need to transcend the limitations of traditional biases in order to aid practitioners faced with real world, and increasingly wicked problems. Montuori (2013) described a practical limitation of mono-disciplinary research that is particularly poingient for sport:

> Disciplinary approaches have historically produced some excellent research, but they are also limited and limiting…The problem is not that such research is not interesting or important per se, but that it gives us a partial view, and this view is often – despite warning labels – taken to be the whole. Using that partial view as a lens through which to view the entire phenomenon becomes problematic, particularly for practitioners. Unlike academic disciplines, life does not break down into neat categories and disciplines, and we ignore this at our own risk (p.46).

Both trans- and multidisciplinary approaches aim to alleviate the limitations of mono-disciplinary research and construct a more holistic, "workable" picture to aid practitioners. The creativity development framework is an admirable example that aids the transition toward a more holistic view of creative development in team sport (Santos et al., 2016). However, while multidisciplinarity represents an important step in the right direction it can remain susceptible to the mono-disciplinary limitations of its constituent parts. Unlike transdisciplinarity (elaborated upon below), the paradigmatic limitations of combined disciplines can remain in multidisciplinary approaches. A related issue concerns the inadvertent amalgamation of disparate fragments of decontextualized knowledge founded in distinct theoretical (or philosophical) perspectives with incongruent ontological and epistemological foundations (Sefotho, 2015).

In sport, multidisciplinary frameworks aiming to aid practitioners appear unconcerned or unaware of the intra-paradigmatic limitations of the "quantitative, sport science lens," leaving processes, procedures, systems and practices in sport susceptible to "organismic asymmetry" (Dunwoody, 2006; Davids and Araújo, 2010). This bias displays limited recognition of the inter-relatedness of human and ecological sub-systems (Balagué et al., 2017) and the sociocultural forces (Toohey et al., 2018) that characterize environmentally situated constraints emerging from sociocultural historic macro contexts (Rothwell et al., 2018, 2019) (detailed in the following sections). Such oversight facilitates a linear picture of human development that contradicts the everyday contexts and unpredictable situations that sport practitioners find themselves in (Bowes and Jones, 2006). In the context of this paper, a major concern with approaches to mono- and multidisciplinary sport science is that they fail to address the implications for practice of the rich complexity of social systems (Alhadeff-Jones, 2009). This limitation fails to comprehend the socially and culturally embedded person-environment interactions at the core of human development and creative moments (Glăveanu, 2012; Eisler et al., 2016; Glăveanu et al., 2019). This current weakness in sport science could be remedied by practitioners adopting a transdisciplinary platform to underpin their work. Sports development frameworks aimed at practice should emerge from, and evolve in, interaction with the sociocultural context in which practitioners are embedded. This embeddedness will ensure that any framework is inherently contextualized and co-created from the bottom up as much as the top down. This is the promise of transdisciplinarity, because in contrast to mono-,

multi-, and interdisciplinary approaches, transdisciplinary inquiry foregrounds the need for a reciprocal *top down, bottom up dialectic* (Songca, 2006) between academics, practitioners *and* athletes.

At the heart of a transdisciplinary approach is the recognition that no one academic discipline can provide appropriate methods and data to illuminate the inter-relatedness of a particular issue (Songca, 2006). Instead, transdisciplinarity challenges researchers to better appreciate the indivisible interconnections between our biological and social systems (Balagué et al., 2017) and overcome a culture of intra- and inter- disciplinary competition (Songca, 2006). Ideas acknowledged by Poincaré (the founding father of dynamical systems theory), who noted that science is a system of relations, and that it is in relations alone that objectivity must be sought and, consequently, that "mathematicians do not study objects but the relations between objects…" (Poincaré, 1905, p. 20; translation by George Halstead, 1907).

Compared to traditional (mono-disciplinary) approaches, transdisciplinary inquiry is characterized by four defining features (Montuori, 2013). Specifically, it: (a) is inquiry-based rather than discipline-based, (b) integrates rather than eliminates the inquirer from the inquiry, (c) adopts a meta-paradigmatic rather than intra-paradigmatic approach, and (d), utilizes complex systems theorizing and embraces complexity rather than a reductionist perspective (Montuori, 2013). Transdisciplinary inquiry can be thought of as an *undisciplined approach*, inspiring research projects that balance "methodological groundedness and epistemological agility" (Haider et al., 2018, p. 191). Developing a generative space, transdisciplinarity can utilize methodologies that view phenomena from other, broader, and more holistic perspectives and embrace systems with multiple ontologies (i.e., order, complexity and chaos) and nuanced interactive relationships between system components (Snowden and Stanbridge, 2004). A transdisciplinary approach is particularly generative for appreciating the sociocultural conceptualization of creativity (Glăveanu et al., 2019) within complex and dynamic sport performance environments (Araújo et al., 2006). While it is by no means a panacea for wicked problems, or a silver bullet to avoid historical bias or epistemological hegemony, transdisciplinary inquiry provides a more ontologically accurate, and generative, point of departure to understand a particular wicked problem; that is, developing creativity and reaching our human potential, in sport and life.

Dynamic Systems Theory: A Transdisciplinary Foundation

Recognizing the need for transdisciplinary inquiry, in this paper we: (a) adopt the broad scope of inquiry needed to comprehend creative development; (b) highlight knowledge as an embedded web of interconnected relations (Montuori, 2013); and (c) embrace dynamical systems theory as a meta-paradigmatic approach. Our approach signifies that general concepts of dynamic systems theory are valid for all levels of analysis, from molecules to social systems (Balagué et al., 2017). We aim to analyze key issues and critique outdated paradigms while synthesizing novel concepts from ecological dynamics and ecological psychology alongside established concepts from socio-cognitive psychology. At the core of this conceptual analysis, we argue for a re-conceptualization of the concept of human creativity to emphasize the interaction of social, cultural, historic, and relational dimensions on achieving potential and expertise (Eisler et al., 2016). This perspective suggests that the very essence of creativity "is one of connection and/or interdependence rather than abstractions and/or independence" (Eisler et al., 2016, p. 17). To explain these perspectives in the sporting realm we utilize the theoretical framework of ecological dynamics (Araújo et al., 2006).

Ecological Dynamics

The seeds of ecological dynamics emerged from the work of Davids et al. (2001), Beek et al. (2003), and Warren (2006). These authors started to recognize the conceptual adjacency of key concepts and tools in dynamical systems theory and ecological psychology applied to sport. Ecological dynamics as a theoretical framework (Araújo et al., 2006) was proposed to build on these original attempts. This framework also integrated key insights from the complexity sciences, evolutionary sciences and constraints theory (Newell, 1986; Kauffman, 1996), especially emergence and system self-organization under interacting constraints, to explain human movement behavior and moments of creativity within sport performance and motor learning contexts.

Within ecological dynamics, non-linear interactions between system components provide a framework for understanding the exploratory fluency and flexibility of adaptive and creative movement solutions (Hristovski et al., 2012). Fluency is considered the generation of numerous, functional performance solutions (Seifert et al., 2014) and flexibility refers to the variety of class solutions (Kim, 2006). Within fluid athlete-environment systems, we propose that moments of creative movement are emergent and arise from a combination of dynamic constraints. Specific moments of creative movement can be conceptualized as emergent behavioral tendencies arising under specific constraints, which elicit adaptive actions. The implication is that specific constraints (i.e., task or sociocultural) can be manipulated and exploited in practice designs to provide opportunities or invitations (affordances, detailed later) for creative behaviors to emerge from athletes. In the following sections, we aim to expand on this position and develop the ecological dynamics rationale by clarifying the following proposal: cultivating a constellation of constraints within a context, culture or *form of life* (Wittgenstein, 1953; Rietveld and Kiverstein, 2014) can facilitate creative development. In particular, we discuss how complex system and transdisciplinary approaches resonate with conceptual frameworks that recognize the irreducible embeddedness of an athlete and a sport environment (Gibson, 1966; Bronfenbrenner, 1979; Henriksen et al., 2010; Sheldon et al., 2011; Mahoney et al., 2014; Henriksen and Stambulova, 2017). We propose that sport "teams and individuals, are systems that face ill-defined problems" (Hristovski et al., 2012, p. 26) and that new models of pedagogical practice should be predicated on notions of athletes and sports

teams as complex adaptive systems (Chow et al., 2007; Davids, 2015; Silva et al., 2016).

A HUMAN ECOLOGY OF COMPLEX ADAPTIVE SYSTEMS

Gibson's (1966) approach to ecological psychology emphasized the interdependence of an organism and its environment (Araújo and Davids, 2009). Applying Gibson's approach to human development, Bronfenbrenner's (1979, 1995, 2005) *bioecological model* provides a reference point to understand the athlete-environment relationship as a particular ecological niche (or human ecosystem). Bronfenbrenner's model suggests humanistic and psychological needs are satisfied, allowing psychosocial skills to evolve, through a person's embeddedness within particular sociocultural contexts (Larsen et al., 2013). Holistic life skills and psychological constructs (e.g., identity, mindset, and motivational profile) evolve while people are embedded (i.e., contextualized) within different environments (McAdams, 1995). The multi-level personality in context model (Sheldon et al., 2011) highlights an individual's social-entrenchment as a fundamental influence on the satisfaction of basic psychological needs (Deci and Ryan, 1985). Variability in satisfaction of basic psychological needs might facilitate or thwart many development processes, including: (a) enculturation (Crotty, 1998); (b) acculturation (Kim and Omizo, 2003; Sam and Berry, 2010); (c) enskillment (Ingold, 2000); (d) internalization of behaviors (Deci and Ryan, 2000); (e) assimilation of values (Deci and Ryan, 2000); and (f), humans encompassing natural growth tendencies (Vansteenkiste et al., 2006). System, multilevel, and/or ecological approaches to human development provide complementary frameworks to comprehend the complex human sub-systems and development processes that are constantly modified by our experiences and relationship with the surrounding environment (Bowes and Jones, 2006; Montuori, 2012). These concepts are beginning to be applied to athlete development. For example, Henriksen et al. (2010) adapted Bronfenbrenner's bioecological model (Bronfenbrenner, 1979) and defined the athlete talent development environment (ATDE: see **Figure 1** for an example), as:

> ... a dynamic system comprising (a) an athlete's immediate surroundings at the micro level where athletic and personal development take place, (b) the interrelations between these surroundings, (c) at the macrolevel, the larger context in which these surroundings are embedded, and (d) the organizational culture of the sports club or team, which is an integrative factor of the ATDE's effectiveness in helping young talented athletes to develop into senior elite athletes (p. 160).

More recently the holistic ecological approach (Henriksen et al., 2010; Henriksen and Stambulova, 2017) has been applied to football player development (Larsen et al., 2013, 2014) and adapted into a football specific athlete talent development environment (**Figure 1**). This holistic picture of player development (**Figure 1**) is currently guiding research and education practices at AIK Football Club, Stockholm, Sweden (Vaughan et al., 2017).

Considering each athlete-environment relationship (**Figure 1**) as an interaction between complex adaptive systems requires an appreciation that individuals and environments co-exist as open, dynamic, and nested systems. Open systems, in contrast to closed systems, are capable of exchanging energy and information within the surrounding ecology (i.e., at a macro and micro scale) (Von Bertalanffy, 1950; Ashby, 1956). It is from the interactions of such complex adaptive subsystems—neurobiological, psychosocial, socio-cognitive—that creative behaviors might materialize, emerging through the dynamic, fluctuating relationship between the individuals and their environment (Davids et al., 2013). Montuori (2011) suggested that once appropriate fluctuation (i.e., disequilibrium) is created by increasing system complexity, a critical (bifurcation) point is reached. At this moment, the system can move in multiple directions, due to the system property of metastability (Kelso, 2012; Passos et al., 2016) and if a different state of self-organization (e.g., a potentially creative behavior) does not emerge, the system returns to a previous state. It is proposed that transdisciplinary knowledge is needed to understand the emergence of behaviors in self-organizing systems.

One characteristic of living (open) systems that helps conceptualize the extent of information exchange with a performance environment is disequilibrium. The more open the system, the greater the opportunities for exchanges, interactions, and exposure to experiences of difference, novelty, complexity, and functional disequilibrium (Montuori, 2012). As one example, the more open the athlete-environment system, the greater the movement variability available to support adaptations, and the greater the potential for creative moments (Orth et al., 2017). In cognitive psychology, the suggestion that a wide breadth (openness) of attention (i.e., perception, attentional style or focus) is facilitative for creative performance (Carson et al., 2003; Friedman et al., 2003; Healey and Rucklidge, 2005; Hristovski et al., 2011) might give insight into an aspect of openness of actions, perception and cognitions. In an ecological dynamics rationale of skilled movement and coaching praxis, athlete openness for interactions within a performance environment is considered as attunement and utilization of affordances.

Affordances, Exploratory Behavior, and Creative Moments

Affordances are opportunities or invitations (Gibson, 1979; Withagen et al., 2012) for actions that emerge as athletes interact with critical information from the environment (Travassos et al., 2012). Within ecological psychology, information can be perceived as relational and influenced by the specific intentions of the athlete and opportunities to act within the environment (van Dijk and Rietveld, 2017). Therefore, affordances emerge when lawfully-specified possibilities and athlete intentionality (i.e., goal directed behavior) are coordinated (Turvey, 1990). When "perception is of affordances (opportunities for action)" (Araújo et al., 2017, p. 10) then "behavior can be understood as self-organized under constraints" (Araújo et al., 2017, p.

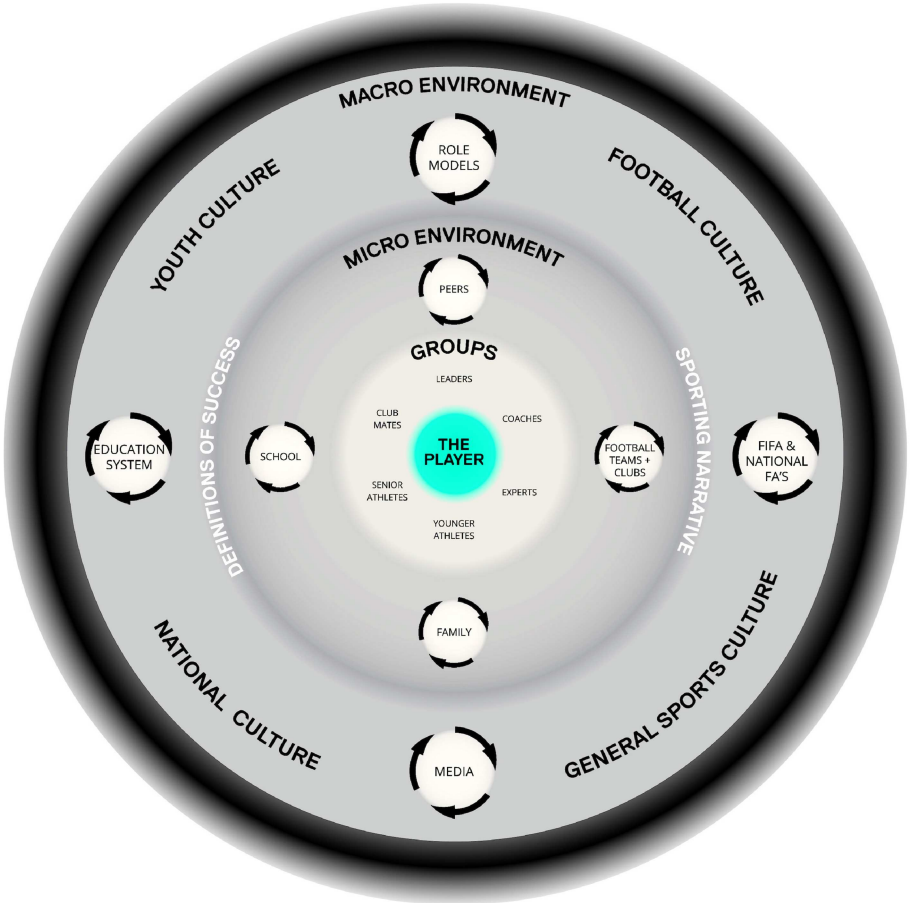

FIGURE 1 | Illustrates the ecological context of football player development. Originally adapted from "Athlete Talent Development Environment," by Henriksen et al. (2010), reproduced here with permissions from the Player Development Project Copyright 2017.

13). The organization of an athletes' behavior is not imposed from inside (e.g., the mind) or outside (e.g., reinforcement contingencies, or coach instruction) but emerges in a constant dynamic with the performance environment (Araújo et al., 2017). Providing a departure from traditional approaches to creativity, and aligned with these ideas Orth et al. (2017) rejected the idea that "individuals first generate an idea in their mind, which is then enacted in behavior" (2). Supporting the concept of behavior as self-organized under constraints Orth et al. (2017) clarify that, "rather than referring to ideas that are uniquely generated by a (creative) cognitive system, we use the term creative as a descriptive for unfolding actions that are original (relative to the individual or group) and functional (i.e., they support task success)" (2 italics in original). Therefore, the design of tranining environments and manipulation of constraints becomes focal for practioners aiming to foster exploratory behavior and creative moments.

Exploratory behaviors emerge from the metastable dynamics of system self-organization. It is within the self-organization of intertwined action, cognition, and perception processes that constraints impinge upon these systems and influence our movement behavior (Hristovski et al., 2012). Creative moments might arise from the idiosyncratic configurations and interactions of systems continually shaped by the sociocultural, personal, environmental, and task constraints in each athlete-environment interaction (Hristovski et al., 2012). In sport contexts, the interdependence of affordances and effectivities (individual action capabilities) helps to capture the relationship between performer constraints and elements of the environment (Fajen et al., 2009; Lopez-Felip and Turvey, 2017). From the perspective of developmental psychology, learning about affordances requires children to explore novel activities which might expand their effectivities and diversify skills (Gibson, 1988). Exploratory activities involve the sampling of varied movement opportunities—sport, dance, martial arts and general play (Côté and Ericsson, 2015; Davids et al., 2017)—available within a *form of life* (introduced below). As a child's perceptual systems develop, exploratory activities are used to discover affordances relevant to their current stage of development. In other words, "as new action systems mature, new affordances open up and new 'experiments on the world' can be undertaken"

Dependent upon their stage of development and experience, each athlete will be open to certain affordances and closed to others in the landscape. To exemplify, in football, analysis of competitive performance at under 17 and senior professional levels, may reveal that the there is less time and space to shoot at a senior level. The implication is clear for the design of training sessions for the younger age group. Athletes of varying developmental capacities might be assigned different *challenge points* (less time and space progressively) in a shooting practice and work through different shooting tasks at their own pace, sampling specific actions and exploring their creative potential for creating goal-scoring opportunities (Santos et al., 2016) by concurrently expanding effectivities and discovering affordances. The emergence and gradual acceptance of a "toe poke" finish (scoring shot) in football is a relevant case. A legitimate skill in futsal (5-a-side indoor football, whereby time and space are reduced) the "toe poke" was initially ostracized by many in football. However, a number of high profile goals (Maradona, World Cup 1986; Romário, World Cup 1994; Ronaldo, World Cup 2002; Bradley, World Cup 2014; Oscar, World Cup 2014, see FIFATV, 2015) have been scored with goalkeepers seemingly deceived by the speed and lack of "back lift" when shooting. It is possible that futsal experience in developing athletes may enrich their skill sets so that there is potential to exploit a toe-poke to deceive defenders and a goalkeeper when there is restricted time and space in the penalty area in association football. Furthering understanding of how creative potential for specific actions might be explored in practice, Hristovski et al. (2012) identified how small manipulations of a task constraint (e.g., scaled distance of an athlete to a punching bag) resulted in variations of exploratory breadth, fluency, flexibility and originality of movement behavior (punches). The affordance landscape confronting the trainee boxers was significantly changed with variations in scaled distance to the punch bag, resulting in different values of scaled distance affording the emergence of different hitting actions.

Recent studies within multiple team sports (e.g., Headrick et al., 2012; Orth et al., 2014) have demonstrated how decision making and the coordination of action are adapted to changing task constraints that alter the detection of critical information: "Critical information sources (i.e., affordances and action capabilities) continuously shape intentions and enhance decision-making, planning and organization, during goal-directed activity" (Davids et al., 2013, p. 23). These ideas suggest that as expertise develops, the detection of critical information could be progressively scaffolded by task constraints that promote (potentially novel) critical information sources. For example, football players might become attuned to gaps between defenders, then spaces emerging between lines of defenders, and perhaps even the weight distribution (knee and hip angles) of a defender when attempting to dribble past them in a football match. Such information might prove critical in discerning the balance of a defender, and light reflected from these body parts can provide optical information for an opportunity/affordance to dribble.

A Non-linear Pedagogical Framework

Founded in the ecological dynamics rational, non-linear pedagogy aids practitioners in attempting to scaffold athlete attunement to critical information in a performance environment. The pillars of non-linear pedagogy are "pedagogical principles that emphasize representative learning designs; manipulation of task constraints; infusion of movement variability; establishing close information–movement couplings; and the modification of attentional focus instructions" (Chow et al., 2016, p. 61). We propose that by first identifying and then manipulating (sociocultural, task, and environmental) constraints on learning, sport coaches might be able to design practice environments that more readily afford opportunities for learners to explore functional performance solutions, develop skill and enhance their creativity. Such practice session design would support the self-organization and adaptability of athlete behavior in relation to changing constraints in the sporting environment (Esteves et al., 2011). An example of football practice session design and constraint manipulation founded on the principles of non-linear pedagogy can be seen in **Video 1**.

This type of pedagogical approach aims to avoid the traditional tendency in sport to rehearse and reproduce specific actions proposed by a teacher or coach (Chow et al., 2016). "Within the framework of non-linear pedagogy, a skill and more generally talent, is not a trait possessed by individuals alone but a property of the athlete-environment system subject to changing constraints" (Hristovski et al., 2012, p. 27; see also Davids and Araújo, 2019). An important point to note is that task, environment, and performer constraints are fundamentally influenced by sociocultural constraints (Araújo et al., 2010; Araújo and Davids, 2011; Hristovski et al., 2011). Due to the sociocultural embeddedness of the interactions between task, athlete, and environmental constraints, experience differs in myriad ways. Each individual might perceive and experience the performance landscape (shaped by many influences, including interdependence of affordances and basic psychological need satisfaction) differently and, therefore, engage in differential exploratory (potentially creative) behavior as a result of their unique athlete-environment system (Hristovski et al., 2012). Therefore, there is the need to recognize that any application of principles of non-linear pedagogy takes place in a sociocultural context, and that this context, plays its role in affordance emergence.

A Form of Life, Affordances, and Football Playing Styles

Rietveld and Kiverstein (2014) have suggested that affordances are dependent on the skills available within a particular ecological niche, sociocultural context or wider macrosystem (for an illustration see **Figure 1**). Due to their relational nature, the variety of affordances are as rich and varied as the abilities (i.e., skills) socialized by sociocultural practices (i.e., enculturated) (Ingold, 2000). These authors have argued that it is the availability of sociocultural practices (constituted by beliefs, skills, habits, customs, attitudes) that defines a dominant *form of life* or way of doing things (Rietveld and Kiverstein, 2014). A

form of life (Wittgenstein, 1953) can be described as regular behavioral patterns (e.g., movements, ways of perceiving or otherwise) manifest as sociocultural-environmental constraints on the normative behaviors and customs of our communities and cultures (van Dijk and Rietveld, 2017). The relevance is furthered when we appreciate that each sporting context is contained within its own form of life, which will facilitate engagement with some affordances, while limiting interactions with others. For example, compare the opportunities to dance in England and Brazil; will an English or Brazilian form of life (cultural context) afford football players more or fewer opportunities to explore movement potential through dance (Uehara et al., 2018)?

The openness to, and discovery of, novel affordances allows the application and diversification of skill within different aspects of the environment, creating potential novel movement patterns or forms of creative behavior (Rietveld and Kiverstein, 2014). This is perhaps best depicted in football by the (historical) Brazilian style of play and particularly evident in football players exposed to the acculturation and skilling of samba and capoeira, alongside the assimilation of *ginga* and *malandragem* (a culturally endorsed value characterized by cunning, street smarts and trickery) (Uehara et al., 2018). Providing a supportive rationale for the influence of samba and capoeira on creative development, Rietveld and Kiverstein (2014) stated, "by acquiring abilities that flourish in different sociocultural practices than one's own [outside of football], one can come to see new possibilities for action provided by the material environment [when playing football]" (327, words in brackets our addition).

Exploring the relational nature of affordances is essential for creative (movement) professions (Rietveld and Kiverstein, 2014) because it places further emphasis on the need to understand and explore the interaction between the openness of both the athlete and their environment. The openness of the human perceptual system (a sub-system of the athlete) and the openness of the form of life and playing style (systems related to the environment), might become critical interdependent factors in fostering creativity. From this perspective, we propose that it might be beneficial to zoom in and out on the athlete-playing style system and conceptualize it as relevant field of affordances within a form of life (van Dijk and Rietveld, 2017.) In order to do so, it is important that we can justify the playing style as an interdependent manifestation of the wider environment; a network of interdependencies that includes constraints emerging from the macrosystem and other sociocultural contexts and practices (Rossing and Skrubbeltrang, 2016).

Within team sport, the dominant form of life might be conceptualized as the deeply acculturated, socially accepted, and often taken for granted (nationally or regionally or trending) *playing style*. For example, affordances for football interactions, such as risking ball possession with long balls or maintaining ball possession with short passing, will be constrained by the (many interdependent) influences that shape a dominant playing style. Here it is proposed that a playing style is an emergent sociocultural artifact (Rossing and Skrubbeltrang, 2016), which embodies the manifestation of the relational environment when playing football. As an example, consider the case of F.C. Barcelona: In recent history the club has exhibited a style of play that often aims to maximize passing opportunities as affordances to maintain ball possession while simultaneously creating the space needed to score goals. As part of a development process, F.C. Barcelona academy players become attuned to the width of playing areas and simultaneously co-create a varied range of passing affordances which continuously emerge and decay from the co-creation and sharing of space in learning designs. F.C. Barcelona exemplify the hypothesis that the sociocultural context (form of life) influences training session design, player attunement and playing style. The Catalan culture is renowned for an *egalitarian passion for width* which manifests in the co-creation and sharing of space, particularly evident in seventeenth century Catalan gothic church architecture (Hughes, 1992).

Playing styles, both team and individual, emerge from myriad transdisciplinary constraints. These include but are not limited to (a) self-organizing degrees of freedom in a complex adaptive system; (b) the culturally defined task (challenge or goal); (c) dynamic affordance landscapes; (d) socio-cognitive motivational climates; and (e), sociocultural values and narratives. Too often, dominant playing styles tend to reinforce movement reproduction and conformity, limit engagement with exploratory affordances and restrict deviation from prescribed behaviors (Hristovski et al., 2012). Constraining movement behavior, in this way, will limit an athlete's capacity to become progressively attuned to information that specifies the rich abundance of affordances within a particular sporting environment (Rietveld and Kiverstein, 2014), thus limiting athletic potential.

Sociocultural Constraints

Coaches working within one cultural context too often focus on the content—*the what of coaching* (session plan, game model, tactical plan)—taking for granted the culturally constituted methods of delivery—*the how of coaching* (Stambulova and Ryba, 2014). Recognizing coaches as agents working within complex adaptive systems (Bowes and Jones, 2006), subject to sociocultural constraints, reinforces the need to reflect on the contextualized, culturally sensitive *how of coaching*. *What* coaches direct athlete attunement toward (i.e., awareness of spaces, gaps, passing opportunities, defenders balance) and *how* (i.e., pedagogy; session design, questioning, and co-creating) attunement is directed is subject to the sociocultural constraints (perhaps representing the subconscious *why*) that shape group cultures, forms of life and playing styles. Coulter et al. (2016) highlight how sociocultural constraints might emerge to shape playing style when explaining problem solving within a group culture. They suggested that if a group (i.e., team) problem is solved repeatedly, in the same way, the solution (e.g., a pass/dribble etc.) becomes an evident truth accepted within the group culture by those group members. When accepted as an evident truth, this solution can become a sociocultural constraint that influences future problem solving and movement behavior of group members (players) and future group members. Sociocultural constraints might be considered as an explanation for the emergence of traditional, distinct playing styles. For example, Brazilian football players and teams were once characterized (stereotyped?) by flair, creativity, and flamboyant dribbling originating from

and reinforcing their own form of life and playing style; while the historical British Isles' approaches to football have often been characterized (stereotyped?) by direct long balls, hard tackles and risk-averse football, typically shaped by perceptions of rationality and hyper-masculinity in traditional forms of life.

Sociocultural constraints exemplify that "humans adapt to their social-ecological surroundings in complex ways" and support the rationale "that people's enduring cognitive structures, including values, are part of that adaptive process" (Manfredo et al., 2017, p. 776). When investigating values as constraints on perception-action, Hodges and Baron (1992) suggested that "ontologically, values are global constraints on an ecosystem" (270). They provide the formative conditions for the ecology while also shaping its dynamics and constraining the emergence of new ontological, epistemological or ethical features. "Thus, values are the *intentions of the world as a self-organizing system* in the sense that they are the ends toward which the ecosystem as a whole is directed" (Hodges and Baron, 1992, 270 italics in original). Critically, Hodges and Baron (1992) stated that "without the *higher-order constraints* we have called values, we think such an analysis of perception-action cycles, particularly in a sociocultural context, will remain enigmatic" (270 italics in original). In F.C. Barcelona (micro environment), an *egalitarian passion for width* might represent a key value and sociocultural constraint (emergent in the macro context) constituting, constraining and reinforcing the clubs unique playing style. A playing style (or football ecological niche) in which players perceptual systems and effectivities develop in interaction with an intention to share space and create a diverse range of passing opportunities (i.e., affordances), manifest from the egalitarian passion for width.

Toward Practical Considerations

Within sport, we ought to consider the socializing influence of clichés, coach instruction, and fan feedback (resulting in the UK, in shouted commands like "get stuck in," "second ball," "mark space," "play simple," "attack," "dominate"), especially as they relate to playing styles (termed an organization's "DNA") and player intentionality (i.e., goal directed behaviors). It becomes particularly appropriate to appreciate *what* critical information is privileged by such communication and *how*—in its delivery, by coaches or significant others—communication influences the extent of athlete attunement to (critical) information sources. *What* critical information an athlete attends to might determine access to affordances within each ecological niche (form of life/playing style). Currently, athlete openness to affordances (and therefore opportunities for creative movement) might be constrained by the abilities (effectivities or skill sets) of those within their ecological niche; form of life; playing style; team; club; culture; nation; global sporting community—many nested systems. From an objective perspective, Rietveld and Kiverstein (2014) stated that affordances are more extensive than standardly recognized. Recognizing the myriad range of possible movement opportunities afforded to football players Lopez-Felip and Turvey (2017) describe the interdependence of the player-environment system as one whereby the system "constituents are non-denumerable and its semantics is functional, dependent on 'when,' 'where,' and 'who.' It is a time-dependent and context-dependent semantics" (Lopez-Felip and Turvey, 2017, p. 169). Lopez-Felip and Turvey (2017) illuminated affordance-effectivity interdependence as reciprocal dispositional properties, such that when an organism is conjoined with its environment, the (re)organization of the system degrees of freedom emerges based on the commensurability between the particular kind of physical disposition (*affordance*) and the properties of the organism (*effectivities*) (Turvey, 1992). "Situation X affords activity Y for organism Z on occasion O if and only if X and Z are mutually compatible on dimensions of relevance to Y. Organism Z effects activity Y in situation X on occasion O if and only if Z and X are mutually compatible on dimensions of relevance to Y" (169). Creativity plays its physical role within this myriad arrangement of degrees of freedom and hints at the underlying thermodynamic processes when higher order states emerge from such non-equilibrium self-organizing systems.

The complex, functional semantics at the core of team sports might pose coaching itself as a wicked challenge. Knowing (or believing that we "coaches" know) *what* an athlete should be attuned to (critical information sources) might guide learning and or suppress creativity by creating conformity toward a perceived "ideal" performance model or technique (Hristovski et al., 2011). Rather, the suggestion is that *what* an athlete becomes attuned to (i.e., changing spaces, teammate and opposition movements, opportunities for football interactions) within a particular playing style, affords different opportunities for fulfilling human potential through movement, skill, and creative development. For example, I may perceive (be attuned to) affordances for direct long balls and remain unaware of concurrent opportunities to combine short, quick passes in potentially creative ways. This understanding is critical for coaches and other practitioners involved in continuously shaping (and re-shaping) the player development environment. The *what* of athlete attunement is critical in determining the information (relational nature of affordances) an athlete attends to and therefore the skill they develop; however, *how* athletes become attuned might hold potentially more influence in regard to ongoing engagement with, and exploration of affordances. Crucially, affordances only emerge to be engaged with if perception is intentional. Therefore, intentionality (i.e., goal directed behavior) and lawfully-specified possibilities must be coordinated for an affordance emergence (Turvey, 1990). van Dijk and Rietveld (2017) suggested that an individual manifests skilled intentionality in the context of their form of life (or playing style) by "considering the skillful responsiveness to multiple nesting and nested affordances simultaneously. i.e., the responsiveness to a whole *field of relevant affordances*" (van Dijk and Rietveld, 2017, 9 italics in original).

This is critical when considering *the how of coaching*; how do we design practice sessions that shine a light on key/nested affordances and utilize pedagogical strategies

to foster an intentionality open to creative adaptation (see **Video 1**) rather than controlled by cultural clichés, authoritarian instructions, and performance models? For example, when coaches instruct players to pass wide or switch the play (as part of a performance or game model), they coerce behavioral outcomes rather than educate attention or attunement. Controlling commands aimed at specific behaviors inhibit the development of learners in achieving their potential. This prescriptive pedagogical methodology often disregards the critical information or lawfully specified possibilities (spaces, gaps, teammate, and opposition dynamics) that coordinate with intentionality of individual learners (e.g., maintain ball possession and find the time and space to score a goal) to form the affordances that invite movement. The risk is that instructional/coercive/controlling coaching results in attentional fixation and limits one's ability to remain open to critical information available in performance environments. It is recommended that future research explore the interdependence between player intentions and the form of life they are embedded or acculturated within. Transdisciplinary inquiry incorporating ethnography and guided by the skilled intentionality framework might prove generative in this area (van Dijk and Rietveld, 2017).

CREATIVE DEVELOPMENT IS A WICKED PROBLEM: A CONTEXTUAL ANALYSIS

The importance of contextual/cultural sensitivity (as highlighted in the sections above) cannot be understated when tackling wicked problems and undertaking transdisciplinary inquiry; fundamentally "transdisciplinarity requires us to question values and cultures that were transmitted unconsciously during our professional training" (Songca, 2006, p. 227). A contextual analysis is a productive approach for investigating the sociocultural contexts in which phenomena are historically constructed (Uehara et al., 2018). The following contextual analysis demonstrates a transdisciplinary point of departure and introduces literature that illuminates some social, cultural, and historic constraints on creative development (Hristovski et al., 2012), and transdisciplinary research (Bocchi et al., 2014). To locate this contextual analysis we "zoom out" to appreciate the all-encompassing ecological context called the macrosystem. Of which Bronfenbrenner (2005) said "the macrosystem may be thought of as a societal blueprint for a particular culture, subculture, or other broader social context" (150) containing "the overarching pattern of micro-, meso-, and exosystem characteristics of a given culture, subculture or other broader social context" (cited in Uehara et al., 2014, p. 8). Critically, a macrosystem carries the information, ideology, and values that influence events and experiences at embedded levels. For example, the macrosystem influences contextually embedded microsystems—classrooms and coaching sessions—in which children develop (Kasser and Linn, 2016). We illustrated this perspective using the football specific example of an athlete talent development environment in **Figure 1**. The following analysis illuminates the wickedness of the challenge that constitutes developing creativity and reaching our potential due to macro level sociocultural constraints.

Overly-Competitive and Comparative Contexts

Embracing transdisciplinarity and recognizing creativity as a collaborative interdependent endeavor (Eisler et al., 2016) requires critical reflection on the many societal systems (e.g., economic, media, educational, and sporting) that promote overly-competitive/comparative contexts (Kasser et al., 2007). Here, for example, it could be argued that wicked problems like climate crises (Kasser, 2009), dis-engaging educational programs (Taylor et al., 2008), and highly controlling sporting environments (Kidman and Lombardo, 2010) emerge from macrosystem constraints and the path dependency of what authors have termed "American corporate capitalism" (Kasser et al., 2007). Path dependency is a system process demonstrating that once a system is set on a development path, the historically derived (paradigmatic) modeling and emergent organizational structures constrain its trajectory (Djelic and Quack, 2007). American corporate capitalism (as opposed to Nordic, Asian and developing world versions of capitalism) is described as a dominate brand of capitalism that spread via globalization and had the largest worldwide influence at the turn of the millennium (Kasser et al., 2007). The ideology, values and path dependency of corporate capitalism continue to shape social contexts and organizational structures that over-emphasize individuality, competitiveness, hierarchy, and extrinsic rewards, often to the detriment of psychological wellbeing (Kasser and Linn, 2016) and at the expense of learning, creativity, and innovation in developmental and performative tasks.

The Corporate Capitalist Macrosystem

Alongside toxic marketing and profit-driven educational philosophies, Kasser and Linn (2016) state that there are "many other ways in which the corporate capitalist macrosystem affects the exosystem structures and microsystem experiences that, in turn, influence children's development" (145). At the level of the individual, the psychological influences of corporate capitalism promote high materialistic value orientations that make people more likely to compete and less likely to collaborate (Sheldon et al., 2000). Over-emphasis on extrinsic rewards and competition is likely to reinforce social comparison, divisions between sub-groups, and insecurities, fear of failure, scarcity mentalities, and contexts that reproduce the controlling behaviors of teachers and coaches, currently evident in many educational environments (Taylor et al., 2008). An over-emphasis on internal and external competition has led to corporate organizational structures and governance practices being applied to elite and grassroots sport (e.g., professional football clubs and national governing bodies in sport) and education (schools and universities lumped together in national and international "league tables," see Halffman and Radder, 2015). This approach might induce controlling (extrinsically rewarded) social contexts that fail to satisfy basic psychological needs, eroding intrinsic and self-determined forms of motivation

that subsequently shape thoughts, affect, and behaviors (Deci and Ryan, 2000; Vansteenkiste et al., 2010). The problem with corporatist methods of working (e.g., Taylorism) is that they have been designed to encourage conformity and operational efficiencies in mechanistic processing systems (Myers and Davids, 1993; Rothwell et al., 2018). Such controlling management processes often (extrinsically) reward and reinforce individual competition and compliance at the expense of collective, potentially creative collaboration. Research has long suggested (Davids et al., 1991; Smith and Davids, 1992; Myers and Davids, 1993) that the reductionist, industrial paradigm, founded on the metrical regulation of Taylorism, might privilege a path dependency in education and training that focuses on (reductionist) *simplistic thinking*, in contrast to the contextualization and inter-connectivity that inspires *complexity thinking* (Bocchi et al., 2014).

Conformity and Competition

According to Guilford (1959) problem solving occurs in diverse ways, through convergent and divergent thinking. However, education (on and off the field of sport) seems to mirror colonial/industrial/corporate traditions and focus on conformist, orderly, reproductive, and convergent thinking, which produces a reliance on same level, habitual, often pre-determined solutions. In comparison, divergent thinking fosters multiple solutions and was conceptualized as a foundation for creativity (Guilford, 1959). Montuori (2012) explains the controlling, reproductive, and overly mechanical nature of education: "Reproductive Education stresses conformity and homogeneity and suppresses creativity at a time when it is apparent that creativity needs to be mobilized to get beyond the decaying industrial views of modernity and envision new futures, new possibilities, new economic, environmental, social, and cultural and ethical systems" (65). To overcome the suppression of creativity, Barron (1990, 1995) has suggested that the benefits of complexity and variability (conceptualized here, as self-organization and disequilibrium) need to be better understood, promoted and recognized as conditions that inspire adaptive creativity. Recently, Bocchi et al. (2014) called upon educators to challenge the excessively individualistic view of creativity that, created by, and coupled with the conformist nature of many modern societies, has failed to account for the role of the environment in cultivating a generative space for ideas to flourish. Here they noted:

> The problem is that our society is not designed for creativity but for machine conformity. Most importantly it does not support creative ideas. Let's just look at academia; having a good mind in academia means, among other things, to be razor sharp in critique. But we do not learn how to play with ideas, how to explore together, and support "newborn" ideas and allow them to flourish for a while. We immediately learn to attack and critique. In organizations, we laugh at "wild" ideas. We make jokes about people with their odd approaches. So as Oscar [Wilde] put it, art keeps people sane, but it is the environment that kills creativity in people, and arguably kills many creative people (Bocchi et al., 2014, 362 word in brackets our addition).

The work of Bocchi et al. (2014) reinforces the foregrounding of competition and backgrounding of collaboration in many modern societies, a dynamic that might thwart feelings of relatedness a basic psychological need (Ryan and Deci, 2000). Fostering emotional connectedness with others is an important characteristic for teammates in sport but also for theorists addressing wicked problems. The imbalance between competition and collaboration in scientific and coaching communities (see Potrac et al., 2013) might explain the process of *disciplinary purification* and the creation of intellectual silos (Montuori, 2013). Songca (2006) has suggested that: "Boundaries are drawn between the different disciplines and respect, recognition and promotions are acquired by publishing in areas that are related to one's discipline. The climate and culture that emanate from specific individual disciplines is one of competition and not collaboration" (p. 224).

A culture that underscores competing over co-operation keeps extra-disciplinary influences at bay, privileging orderly purity, despite arguments for complex inter- or cross- or even transdisciplinary work. When competition (and self-interest) dominates, educational systems are likely to focus on the extrinsic comparisons and generic measures that inhibit creativity, learning, and subsequent development.

Path Dependency

In sports like professional football, a path dependency emerging from these influences might be exemplified by the "objective" and comparative measures of the English Premier League's elite player performance plan (EPPP) (English Premier League, 2011). The EPPP was developed using misconceived notions of a 10,000 h "performance clock" and appeared to reinforce many outdated machine metaphors mistakenly applied to development of human capacities such as expertise (Campitelli et al., 2015). Mechanistic approaches to coaching (for extensive critiques see Davids et al., 1998; Jones and Wallace, 2005) and reductionist sport science perspectives have been criticized for assuming that human behavior can be conceptualized as being "machine-like" and can be predicted and controlled in highly precise ways (Davids et al., 1991, 1994; Myers and Davids, 1993; Bowes and Jones, 2006).

In relation to creativity, it has been argued that the over-emphasis on competition, self-interest, and individualism spawned from macro constraints, like corporate capitalism, reinforces the myth of "the lone genius" (Montuori and Purser, 1995). This path dependent myth has monopolized the application of seminal creativity research by E. Paul Torrance (Kim, 2006). The Torrance tests of creative thinking have been largely (mis)used to identify *gifted* individuals, even though this was not the creator's intention. Here, Kim (2006) suggested that "Torrance's main focus was in understanding and nurturing qualities that help people express (*develop*) their creativity" (4 italics added). When administrating the tests, Torrance highlighted that environmental factors, like motivational conditions and psychological climate, would have an influence on peoples' creativity (Kim, 2006). However, this contextual line of research was not pursued and considerations of potential effects of motivational/psychological climates remain

relatively underexplored. Montuori and Purser (1995) argue that the myth of "the lone genius" has prevented a comprehensive investigation into the social dimensions of creativity and the sociocultural constraints on creativity.

To summarize, we have aimed to illustrate how sociocultural constraints might emerge in interaction with macrosystem path dependency to inhibit the conditions necessary for creative development. As an example (at some levels of analysis) we have considered the tendency of corporate capitalism to foster an over-emphasis on competition rather than collaboration (Kasser et al., 2007). This imbalance might be considered a sociocultural constraint on creativity. Located at the level of the macrosystem, corporate capitalism might inhibit creative development by suppressing people's basic psychological need satisfaction and subsequent internal motivation experienced in the micro environments under its influence, such as workplaces and educational establishments including offices, classrooms, learning and training centers, and academies. Therefore, while calls to foster creativity in daily life (Runco, 2014), education (Robinson, 2009), and team sport (Memmert, 2015) are well-established, many organizational structures and pedagogical approaches remain fundamentally unsuited to fostering creativity due to these often unseen sociocultural and historical constraints.

In previous sections of this paper, we have argued that these constraints, which operate at a communal and societal levels, may be dominated by traditional *forms of life* imposed in bygone eras (see Rothwell et al., 2018, 2019). These forms of life shape the way that learning designs continue to be perceived in educational programs for trainers, teachers and coaches, exemplifying a type of "system capture" and inhibiting the adoption of new pedagogical models for enhancing human potential, innovation, and creative behaviors.

Practical Considerations for Sport, Coaches, Clubs, Sports Organizations, and Conclusions

This conceptual analysis proposes that the first step toward nurturing creative moments (a wicked challenge) in sport, is cultivating an in depth understanding of culture and context alongside a nuanced appreciation of athlete-environment interdependence. We propose that conceptualizing a form of life and sociocultural constraints through the lens of ecological dynamics (Rothwell et al., 2018, 2019), represents a novel avenue in understanding athlete-environment interactions and creative moments. We contend that long-term athletic development and moment-to-moment creativity emerge from deeply contextualized athlete-environment interactions. Interactions that are shaped by, and subject to, a continually changing dynamic of constraints. Constraints that transcend disciplinary boundaries, act over varied timescales (Balagué et al., 2019), and can cascade from macro to micro environments. From this vantage point, practitioners might aim to design movement environments that encourage the discovery and exploration of novel affordances to better foster creative moments for achieving potential.

We propose that the skillful manipulation—dampening or amplifying—of sociocultural constraints on behaviors is central to developing an environment conducive to creativity. Manipulating constraints in the moment and over time (by coaches and other support personnel in football clubs, sports organizations, and governing bodies) can better co-create the environmental conditions, customs, habits, and ways of doing things, in a form of life that constrain and afford creative moments. However, this is by no means a straightforward endeavor, it is wicked challenge whereby sociocultural constraints are addressed at multiple levels. For example, consider a form of life and emergent playing style that promote an *over-emphasis on intra team competition* (often conducive to anxiety) leading to individualistic play. At the level of the micro environment a coach might aim to dampen this influence by designing training sessions with task constraints that require teamwork and collaboration. Concurrently, and at an organizational level, a sports club (or governing body) might aim to de-emphasize (the anxiety inducing) culture of competition between teammates, parents and coaches by removing *best-with-best* "academy" selection at young ages (a change implemented at AIK football club and supported by on-going transdisciplinary research) (Vaughan et al., 2017).

It is important to problematize the manipulation constraints in social systems at multiple levels, recognizing that outcomes are transient and unpredictable and that issues may shift and re-emerge due to the unpredictable consequences of wicked problems. As such, the ways in which sociocultural constraints may be manipulated differ from context to context. What is possible in Stockholm might not be possible in Barcelona. Equally, a club that suffers from anxiety inducing hyper-competition in some team contexts may contain certain players in particular teams who are overly concerned by "not standing out," and or "being a good teammate." Therefore, they require training sessions designed to encourage an exploration of individual solutions to tasks, with rules or constraints that, for example, enlighten dribbling opportunities. In the same club, one coach may be working with hyper-competitive "dribblers" while another coach is concerned that her team are overly-conformist "passers." Here lies the wicked problem and the art of coaching: The point of departure when designing learning environments and cultivating contexts for creativity is a nuanced appreciation of sociocultural constraints that might be amplified or dampened to encourage athlete-environment interactions that foster creative moments in specific contexts. Therefore, what works in one context is often unhelpful in another. This is why it is crucial that any framework aiming to aid practice is flexible, contextualized and co-created from the bottom up as much as the top down. This is the promise of transdisciplinary endeavor, because it foregrounds the need for a reciprocal *top down, bottom up dialectic* (Songca, 2006) between academics, practitioners *and* athletes.

We suggest that future research seeks to explore the sociocultural constraints that continually influence our ecological niche and co-create a form or life, which shapes the available field of affordances needed for advancing potential through learning and development programs. Within the context of

football player development, we suggest that a form of life might be conceptualized as habits, customs, beliefs, experiences, ways of doing things, and attitudes that create a climate/culture in a sport or sports organization. This holistic ecological perspective on skill acquisition encourages educational, pedagogical, coaching, and research approaches to adopt a transdisciplinary process of inquiry and aim to re-conceptualize creativity and human development as one of connection and interdependence within a surrounding ecology of complex adaptive systems. Transdisciplinary approaches guided by the skilled intentionality framework and ethnographic endeavor are recommended as avenues for future investigation (van Dijk and Rietveld, 2017). We also propose that some playing styles, by virtue of the affordances offered to learners and basic psychological need satisfaction in athlete development, might cultivate creative development and well-being more than others. In this way, transdisciplinary lines of inquiry might represent fertile ground for fundamental changes in the approaches we use to enhance learning and development of human creativity both on and off the field of sport.

AUTHOR CONTRIBUTIONS

JV carried out the drafting, conception, and design of the manuscript, wrote the general topics of the article, conceptualized the combination of theoretical models. CM contributed to drafting, conception, and design of the manuscript, ensuring that the ideas presented were appropriately investigated and articulated, critically revised the manuscript for important intellectual content. KD was involved in drafting the manuscript and ensured that the ideas presented were appropriately investigated and articulated with particular respect to ecological theories and system processes. PP revised the manuscript critically for important intellectual content, in particular revising the structure and providing analysis and interpretation of the sociological perspectives and coaching approaches. ML-F reviewed the manuscript for important intellectual content and revised sections articulating concepts from ecological psychology and football praxis.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02090/full#supplementary-material

Video 1 | Football training design founded on the principles of non-linear pedagogy.

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Age Differences, Age Changes, and Generalizability in Marathon Running by Master Athletes

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This study examines the world's Top 100 age class performance times by Master athletes in marathon running. The predominant paradigm for this type of research assumes that the outcomes represent a "virtual" cross-sectional study with important implications about aging. This article critiques this perspective and presents alternative models that include temporal dimensions that relate to cohort differences, age changes and historical transitions. One purpose of this study is to compare these models with respect to goodness of fit to the data. A second purpose is to evaluate the generalizability of findings from the fastest divisional age class quartile to the slower quartiles. Archival listings by the Association of Road Racing Statisticians include a maximum of 100 fastest age class performances in marathon running performances by men and women. This database includes 937 performances by 387 men performances and 856 performances by 301 women. The mean ages are 62.05 years for men and 60.5 years for women. The mean numbers of performances per runner are 6.64 for men and 6.4 for women. Analysis by mixed linear modeling (MLM) indicates best goodness of fit for logarithms of performance time by a model that includes linear and quadratic expressions of age at entry into the database (termed "entry cohort") and subsequent age changes (termed "elapsed age") as variables. Findings with this model show higher performance times in women than men. Rates of increase in performance time are higher at older cohort ages and elapsed ages. Performance time increases with interactions between cohort age and elapsed age, cohort age and gender, and elapsed age and gender (i.e., with greater increases in women than men). Finally, increases in performance time with cohort age and elapsed age are higher in slower than faster performance quartiles, with athletes in the faster quartiles more likely to have multiple data entries and athletes in the slower quartiles single data entries. Implications of these findings are discussed.

Keywords: aging, age trends, human potential, cohort effects, longitudinal trend, physical performance, master athlete

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INTRODUCTION

What Stones and Kozma (1985) and Rittweger et al. (2009) term optimum physical performance encompasses the study of age trends in peak athletic performance. These studies began in the mid-1970s, about a decade after the emergence of competitions for athletes "past their prime" (i.e., aged 40 years and older) – now known as master athletes (Weir et al., 2010). The earliest studies include analyses of running (Moore, 1975; Salthouse, 1976; Stones and Kozma, 1980), track and field

athletics (Stones and Kozma, 1981) and swimming (Rahe and Arthur, 1975; Hartley and Hartley, 1984; Stones and Kozma, 1984). The data for the majority of those studies derive from archival listings of age class records, yearly performance rankings, and medal-winning performances in major championships. The main forms of analysis include simple regressions of performance on age, followed by comparison of the age trends across events.

Rittweger et al. (2009) provide a cogent summary of assumptions about the methodology and applied significance of the preceding approach to modeling human performance potential. First, they propose that "world records . . . can be regarded as results of one of the largest human experiments ever accomplished, taking into account the large underlying sample group, the well-defined criteria and the meticulous surveillance involved" (p. 683). Second, "record data from master athletes can be regarded as a 'virtual' cross-sectional study that can provide important insights into the aging process" (p. 683). Third, master athletes "may be regarded as a model for 'successful' aging" because "they allow assessment of the relative contribution of senescence (i.e., an irreversible biological process) as opposed to sedentarism or co-morbidity" (p. 683).

This author agrees that peak performances by master athletes provide a unique opportunity to study human physical performance potential with a rigor that satisfies the exacting standards of good science. However, questions can be raised about the validity of the other assumptions. For example: do "virtual" cross-sectional age trends provide an adequate representation of effects due to aging? Does an answer to the preceding depend on the type of database available for analysis? Are the traditional statistical procedures still appropriate for analytic purposes? Do age trends in peak performance generalize to those at lower ability levels? The following paragraphs address these concerns.

Temporal Trends Relevant to Aging Research

Cross-sectional trend is one of three temporal trends that Schaie (1977) identifies as relevant to research on aging. The others are longitudinal and historical trends. Cross- sectional trend compares performance differences between individuals from different age groups at a single time of measurement. Researchers refer to these age groups as cohorts, with cohort membership contingent on birth date in studies that sample from the population. Longitudinal trend refers to age changes within a given cohort (or cohorts) when measured at two or more times. Historical effects refer to contextual differences that relate to measurement at distinctive historical periods (cf. Rubin and Rahe, 2010, on masters swimming). Although differentiation among these trends has clear implications for quasi-experimental studies of aging in the general population, Schaie (1977) reasons that the same dimensions have comparable relevance to exploratory designs with sampling biased toward the upper or lower extremes of a normative distribution.

Confounds associated with these temporal trends include the following. Cross-sectional designs confound cohort differences and age changes. Longitudinal designs confound age changes and historical effects. Consequently, any inference that cross-sectional age differences are "virtually" the same as longitudinal age changes is true only in the absence of both cohort differences and historical change.

Schaie (2009) reports about cognitive performance that cohort differences (rather than age changes) are the main reason for discrepant findings between cross-sectional and longitudinal age trends. Because cross-sectional and longitudinal age trends in athletic performance show similar discrepancies (Young and Starkes, 2005), it is reasonable to question whether cross-sectional trends in physical performance also provide what Schaie (2009) terms "fallacious" evidence about aging effects. In attempt to provide an answer, let us consider properties of the databases.

Archived Data on Athletic Performance

Previous research includes two main types of database relevant to athletic performance. "Ordinary" performances include those below peak levels, such as longitudinal data from samples of typical master athletes; all finishers in a given competition, etc. "All time best" performances include age class records; inclusion in Top N rankings, and top finishers in a prestigious competition. Distinctions between these types of data give rise to different expectations about age trend.

Examples of "ordinary" performance data include longitudinal archives that typify long- term master athletes without major injury during the measurement period. The data usually include personal best and less estimable performances but without a framework of interpersonal comparison to justify data inclusion. Such data are subject performance variation due to factors other than aging: for example, waxing and waning of competitive interest, general motivation, training practices, incentives to compete (cf. Medic et al., 2009) and minor injuries. The same factors may also affect performances below the top ranks of competitors in championships or regular competitions. Because aging is only one of many influences on performance in such data, it is unsurprising that performance variation with age tends to be lower than in databases restricted to best ever performance (Stones and Kozma, 1982; Young and Starkes, 2005).

Best performance archives typically collapse the age continuum into 5 years competitive categories. Moreover, the entry and retention of data depend on comparisons with age peers. For example, a record holder in a given age category may become a record holder in a later age category despite a decline in performance across times of measurement. What is important to data retention is performance time relative to age peers not the absolute level of performance. On the other hand, any entry (e.g., in a listing of age class records) may eventually undergo replacement by a subsequent superior performance by the same or another athlete. Because inclusion in such a database depends only on meeting "best ever" criteria, there is no reason to anticipate major differences between cohort differences and age changes.

A final property characteristic of database analysis relates to cohort identification. For archival data with a prolonged time period for inclusion (e.g., "all time" records or performance rankings), athletes with entries in the same age category may

differ in birth date. It is for this reason that Stones and Hartin (2017) broke with tradition by defining cohort membership as age at entry into the database rather than date of birth. Differentiation of cohorts based on age at initial data entry rather than birth date seems reasonable because master athletes differ in the ages at which they begin to compete and/or achieve best ever performances (Rubin and Rahe, 2010). For example, one such classification separates master runners into lifelong athletes, those new to the sport and those returning after many years of absence (Pfitzinger and Latter, 2015).

Analysis of Temporal Trends

Nearly all the studies of "best ever" athletic performances use general linear modeling for purposes of analysis. Such modeling assumes that the residuals are independent, which in statistical terminology implies an absence of correlated error. Correlated error is probable in data that includes repeat measures by some individuals (e.g., the same athlete holds records in multiple competitive events and/or age classes; the athlete appears more than once in annual lists of performance rankings; the athlete finishes near the top in successive championships). Furthermore, the frequency of repeat observations is substantial in archival data on "best ever" performances by master athletes. For example, approximately half the 2007 World Masters Athletics age class records in sprinting, middle distance running, race walking and jumping are multiple entries by athletes, with the other half being single entries (Stones, 2010).

Before this millennium, the use of general linear modeling is understandable because of an absence of readily accessible statistical procedures that enable appropriate analysis of repeated measures in unbalanced designs. Researchers at that time could either ignore the implications of correlated error or exclude repeated measures from the database. However, mixed linear modeling (MLM) procedures are now readily accessible that circumvent the problems of correlated error. In unbalanced designs with repeated measures, MLM procedures assume independence of residuals among individuals (i.e., athletes) rather than observations of those individuals.

Generalizability of Age Trends

A final concern relates to the generalizability of age trends. Because the majority of studies report findings from record or top ranked performances, the generality of trends to lower levels of the ability spectrum remains a matter for conjecture. Moore (1975) considers that the age trends "comprise the marks of many individual athletes but they can be thought of as those set by a "super" runner, one who is in a top condition throughout the life span" (p. 256). He contrasted super runners with "ordinary" runners, whom he hypothesized to be slower but with a similar rate of age decline. Fair (2007) thinks that age trends based on "best ever" performances overcome methodological problems of selection bias (e.g., because of dropout) but might not generalize to those for "average" people. In contrast, Suominen (2010) reasons that selection bias (e.g., because of cohort differences) could result in overestimated age decline in peak performances compared to that in athletes of lower ability levels. However, none of these authors provide empirical support for their conjectures.

This author knows of only four studies that directly or indirectly provide data relevant to such generalizability (Seiler et al., 1998; Fairbrother, 2007; Ahmadyar et al., 2015; Nikolaidis et al., 2019). Although these studies sampled performance differently (e.g., "best ever" versus "ordinary" performances) and some have other methodological limitations, a tentative overview suggests lower performance loss with age at higher performance levels.

The Present Study

The present study evaluates models of temporal trend and generalizability of findings in extensive array of "best ever" performances in marathon running by master athletes. Marathon races attract thousands of competitors from across the world. For example, a 2015 article by a renowned running magazine reports that approximately 1,100 marathon races in the United States attract approximately half-a-million competitors, comprising 44% women and 56% men, with respective mean ages of 36.7 years and 40.4 years (Runningusa.org, 2015). In other words, many competitors are master runners. Studies of age trend in their peak performance times in running consistently show an exponential increase with age (Moore, 1975; Stones and Kozma, 1980, 1981; Baker et al., 2003; Fair, 2007; Rittweger et al., 2009; Knechtle et al., 2014). The specific aims are to evaluate the respective effects of cohort differences, age changes, and historical influences and generalizability of cohort and age change trends across performance levels.

Table 1 summarizes the terms and their relationships in the models analyzed. The traditional model, termed here the Concurrent Age model, predicts performance (P) by age at the time of performance. In terms of date arithmetic, this expression of age equals the difference between the date of the n^{th} performance (D^n) and date of birth (D^b). Where P^n is the n^{th} performance, the model predicts this performance as follows: $P^n = \beta_0 + \beta_1(D^n - D^b)$, where β_0 and β_1 are constants.

What is termed here the birth cohort model exemplifies Schaie's (1977) perspective that date of birth identifies an important dimension in aging research. In order to retain consistency with the Concurrent Age model, the Birth Cohort model decomposes concurrent age into independent components that by date arithmetic equal its value. These components represent historical time of measurement (i.e., performance date) and birth date. They are combined in the Concurrent Age model but separated in the Birth Cohort model. Consequently, this model generates the following predictive expression: $P^n = \beta_2 + \beta_3(D^n) - \beta_4(D^b)$, where β_2, β_3, and β_4 are constants.

Previous research by Stones and Hartin (2017) defines the cohort dimension not by birth date but by age at entry into the database. If the date of entry is D^e, date arithmetic gives entry age (A^e) as the difference between an athletes earliest performance date and birth date (i.e., $A^e = D^e - D^b$). A further term in this Entry Cohort model refers to elapsed age (A^n) as the interval between a repeated entry and the initial entry. Date arithmetic expresses the interval between the nth repeated entry and the entry date as follows: $A^n = D^n - D^e$. This model decomposes

TABLE 1 | Nomenclature and expressions used in modeling.

Nomenclature	Description	Expressions used in modeling
Birth date	Date of birth	$_{D}{}^{b}$
Race date	Date of nth race	$_{D}{}^{n}$
Concurrent age	Age at nth race	$D^n - D^b$
Performance	Performance in nth race	$_{P}{}^{n}$
Entry date	Date of entry into database	$_{D}{}^{e}$
Entry age	Age at entry into database	$A^e = D^e - D^b$
Elapsed age	Interval between a athletes' entry and a repeat entry	$A^n = D^n - D^e$
Equation constants	Coefficients in modeling	$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$
Concurrent age model	The traditional on *10 component model	$P^n = \beta_0 + \beta_1(D^n - D^b)$
Birth cohort model	A two-component model of birth date and race date	$P^n = \beta_2 + \beta_3(D^n) - \beta_4(D^b)$
Entry age model	A two-component model of entry age and elapsed age	$P^n = \beta_5 + \beta_6(A^e) + \beta_7(A^n) = \beta_5 + \beta_6(D^e - D^b) + \beta_7(D^n - D^e)$

concurrent age into components that represent a summation of entry age and elapsed age. It generates the following expressions for the nth performance: $P^n = \beta_5 + \beta_6(A^e) + \beta_7(A^n) = \beta_5 + \beta_6(D^e - D^b) + \beta_7(D^n - D^e)$, where β_5, β_6, and β_7 are constants. This model thereby differentiates between entry cohort differences and age changes.

Based on prior discussion, the hypotheses for the study are as follows:

1. Performance times increase more rapidly at older age levels, with this effect greater in women than men (Stones and Kozma, 1982);
2. Models that decompose concurrent time into components (i.e., the Birth Cohort and Entry Cohort models) provide better fit to the data than the modeling without such decomposition (i.e., the Concurrent Age model);
3. The Entry Cohort model provides better fit to the data than the Birth Cohort model;
4. Performance time increases more rapidly at higher levels of the cohort and age change variables;
5. Performance times show shallower declines among faster than slower runners.

MATERIALS AND METHODS

Data

Historically, the Veterans List of All-Time Rankings by the Association of Racing Statisticians' (Association of Road Racing Statisticians [ARRS], 2017) provides the most comprehensive database on marathon running performances by master athletes. The data include up to 100 best ever running times per 5 years age by gender categories that meet the Association's qualifying criteria. The performances downloaded during February 2018 date from 1963 to 2016.

The All-Time Veterans Rankings contain text files specific to 5 years age groups (40–44 to 90–94 years) for males and females. Each file includes data on performance time, the runner's name and nationality, the date of performance, age of the runner (in years, months, days), date of birth, and place of performance. The maximal number of performances per age group by gender cell is 100, each of which meets a qualifying level intended to produce a consistent set of standards over the age ranges for each gender group. The files for males contain 100 performances for all age categories up to and including 80–84 years.

Thereafter, the number of performances is 33 for age category 85–89 years and 4 for age category 90–94 years. The files for females contain information on 100 runners for all age categories to 70–74 years. Thereafter, the numbers of entries are 69 for age category 75–79 years, 54 for 80–84 years, 27 for 85–89 years, and 6 for age category 90–94 years. Because the two 90–94 year categories contain few observations for either gender, they were collapsed into the 85–89 year category when computing divisional quartile rankings.

Analytic Procedures

Because of a large sample size, the significance level is set at $p < 0.01$. The dependent variable in all analyses is a natural logarithmic of performance time. This logarithmic transformation builds on earlier findings that performance time in running increases exponentially with age; hence an expectation that the logarithm of performance time would closely approximate a linear relationship with age (Stones and Kozma, 1980; Baker et al., 2003). Analyses of the dependent variable use mixed linear modeling (MLM) procedures in SPSS 25. Terms common to all analyses are runners as a random intercept and days elapsed from an athlete's initial entry as a repeated measure, with a scaled identity covariance structure for the repeated measure. Estimation of the coefficients is by maximum likelihood ratios.

For comparative purposes, separate MLM analyses of the Concurrent Age, Birth Cohort and Entry Cohort models include gender, components that identify the models (cf. **Table 1**) and their 2-way interactions as fixed effects. The gender term is categorical and model components are covariates centered on their grand means. Preliminary MLM analyses include models with only linear covariates to those with added quadratic covariates in order to test for any additional curvilinearity.

The main MLM analyses compare the Concurrent Age, Birth Cohort, and Entry Cohort models to ascertain which model provides best fit to the data. The estimation of goodness of fit is by deviance statistics, where deviance is the difference in –2 Log Likelihood estimates between models. Lower values for –2 Log Likelihood indicates better fit. The significance differences in -2 Log Likelihood is given by Chi squared (χ^2) with degrees of freedom equal to differences in the number of model parameters.

A subsequent analysis adds to the best fitting model quartile rankings of performance time. These quartile rankings are within divisional groupings (i.e., age category by gender groups). The purpose of this analysis is to evaluate the generality of temporal trends across a continuum that represents the highest to lowest

levels of performance. A final analysis attempts to clarify reasons that underlie the findings on generality.

RESULTS

Preliminary Analyses

The data include 937 performances by 387 men performances and 856 performances by 301 women. The mean ages are 62.05 years for men (s.d. = 13.61 years) and 60.5 years for women (s.d. = 13.11), with birth dates ranging from 1895 to 1976. The mean numbers of performances per runner are 6.64 for men (s.d. = 7.13) and 6.4 for women (s.d. = 5.5). The mean Elapsed Ages are 36.71 months for men (s.d. = 55 months) and 34.34 months for women (s.d. = 46.18 months).

The distribution of the dependent variable – the natural logarithm of performance time in minutes – approximates normality. It has a mean value of 5.26 (s.d. = 0.28), with moderate skew (1.07), moderate kurtosis (0.94) and a histogram that shows only moderate departure from a normal curve. Pearson correlations of the dependent variable with Concurrent Age – in months – are 0.93 for men and 0.95 for women, which for descriptive purposes indicate strong linear age trends.

MLM Analyses

The preliminary MLM analyses show significantly better fit for all the Concurrent Age, Birth Cohort, and Entry Cohort models after inclusion of quadratic covariates as fixed effects (all $p < 0.01$). Consequently, the following analyses report finding for models with polynomial expressions of their components. **Table 2** shows goodness of fit statistics for Birth Cohort and Entry Cohort models compared to the Concurrent Age model. The findings indicate significantly better fit for the Concurrent Age than the Birth Cohort model but significantly better fit for the Entry Cohort than the Concurrent Age model.

Because of the unexpectedly low fit for the Birth Cohort model, the following analysis queries whether addition of linear and quadratic covariates relevant to Elapsed Age would improve model fit. This extended version therefore subsumes all three temporal dimensions of cohort difference, age change and historical effects. Although the findings indicate better fit for the extended over the original version of the Birth Cohort model ($\chi^2 = -108.667$, $df = 2$, $p < 0.001$), goodness of fit is still inferior to that for the Entry Cohort model ($\chi^2 = 77.794$) despite two additional degrees of freedom. For the sake of completeness, the author must mention that the addition of terms representative of historical transition (i.e., linear and quadratic performance date covariates) results in lower goodness of fit for this extended over the original Entry Cohort model despite two additional degrees of freedom ($\chi^2 = 33.987$). Consequently, the original Entry Cohort model provides better goodness of fit than any other model.

The coefficients in the Entry Cohort model show only minor differences after inclusion of performance level quartiles. Consequently, **Table 3** includes findings for the latter. The findings indicate that performance times (1) are higher in women than men; (2) increase at a higher rate at older ages for both the entry cohort and elapsed age terms (i.e., as indicated by significant and positive quadratic coefficients; (3) increase with the interaction between the entry cohort and elapsed age terms;

TABLE 2 | Goodness of fit of the birth cohort and entry cohort models compared to the concurrent age model.

Model	Number of fixed effect parameters	Number of random effect parameters	Deviations from -2 log likelihood for the concurrent age model	Significance of deviation from the concurrent age model
Concurrent age	7	1	–	–
Birth cohort	12	1	51.285	<0.001
Entry cohort	12	1	−135.176	<0.001

TABLE 3 | Fixed effect statistics for entry cohort model with performance time quartiles.

Model term	Coefficient	significance	95% Confidence interval	
			Lower	Upper
Intercept	5.143	0.000	5.137	5.148
Female	0.182	0.000	0.175	0.188
Male	0	.	.	.
Performance quartile = 76–100	0.074	0.000	0.068	0.079
Performance quartile = 51–75	0.054	0.000	0.049	0.059
Performance quartile = 26–50	0.031	0.000	0.026	0.036
Performance quartile = 1–25	0	.	.	.
Entry cohort	−0.003	0.000	−0.003	−0.003
Entry cohort quadratic	$2.91*10^{-6}$	0.000	$2.78*10^{-6}$	$3.03*10^{-6}$
Elapsed age	0.001	0.000	0.001	0.001
Elapsed age quadratic	$1.97*10^{-6}$	0.000	$1.55*10^{-6}$	$2.38*10^{-6}$
Entry cohort * Elapsed age	$4.64*10^{-6}$	0.000	$4.33*10^{-6}$	$4.96*10^{-6}$
Entry cohort * FEMALE	$2.33*10^{-4}$	0.000	$1.93*10^{-4}$	$2.72*10^{-4}$
Entry cohort * MALE	0	.	.	.
Elapsed age * FEMALE	$2.13*10^{-4}$	0.000	$1.31*0^{-4}$	$2.95*10^{-4}$
Elapsed age * MALE	0	.	.	.
Entry cohort * Performance quartile = 76–100	$2.77*10^{-4}$	0.000	$2.42*10^{-4}$	$3.11*10^{-4}$
Entry cohort * Performance quartile = 51–75	$1.71*10^{-4}$	0.000	$1.38*10^{-4}$	$2.04*10^{-4}$
Entry cohort * Performance quartile = 26–50	$7.17*10^{-5}$	0.000	$3.97*10^{-5}$	$1.04*10^{-4}$
Entry cohort * Performance quartile = 1–25	0	.	.	.
Elapsed age *Performance quartile = 76–100	$3.81*10^{-4}$	0.000	$2.87*10^{-4}$	$4.76*10^{-4}$
Elapsed age * Performance quartile = 51–75	$1.92*10^{-4}$	0.000	$1.02*10^{-4}$	$2.83*10^{-4}$
Elapsed age * Performance quartile = 26–50	$2.26*10^{-4}$	0.000	$1.36*10^{-4}$	$3.16*10^{-4}$
Elapsed age * Performance quartile = 1–25	0	.	.	.

TABLE 4 | Regression of performance time quartiles against age at entry and single or multiple age entries.

Performance time quartiles	Model term	Exponential (coefficient)	Significance	95% confidence interval for Exp(coefficient)	
				Lower	Upper
(76–100)	Intercept	0.107	0.000	0.066	0.174
	Age at entry	1.002	0.007	1.001	1.004
	Single entry	42.626	0.000	23.392	77.676
	Multiple entries	.	.	.	.
(51–75)	Intercept	0.361	0.000	0.269	0.484
	Age at entry	1.001	0.036	1.000	1.003
	Single entry	7.922	0.000	4.930	12.729
	Multiple entries	.	.	.	.
(26–50)	Intercept	0.535	0.000	0.414	0.691
	Age at entry	1.001	0.251	0.999	1.002
	Single entry	3.763	0.000	2.357	6.007
	Multiple entries	.	.	.	.

(4) increase more for women than men with increases in the entry cohort and elapsed age terms; (5) are expectedly higher in the slower than faster performance quartiles; and (6) increase to a greater extent in the slower than the faster quartiles with increases in entry cohort age and elapsed age.

Final analyses by multinomial logistic regression explore reasons why slower rather than faster runners show greater performance deterioration in both cross-sectional and longitudinal trends. The data for these analyses are aggregated within athletes. The target variable is divisional performance rankings (i.e., performance time quartiles), with the fastest quartile as the reference category in an initial analysis. The fixed effect terms include entry cohort as a covariate centered on its grand mean with the elapsed age variable simplified to indicate the presence of single or multiple data entries. Alternate reference categories for the latter are multiple followed by single data entries.

Table 4 shows findings for exponential coefficients (i.e., odds ratios). Compared to the fastest quartile, only the slowest quartile has older entry ages at $p < 0.01$. With multiple entries as the reference category for the nominal variable, the fastest quartile has the lowest likelihood of single entries. The likelihood of single entries increases significantly across quartiles, with the odds of a single entry in the slowest quartile being 42,626 times higher than in the fastest quartile. Conversely, with the slowest quartile and single data entries as reference categories, the odds of multiple entries in the fastest quartile are 42,626 times higher than in the slowest category. **Figure 1** illustrates these findings.

DISCUSSION

The best fitting model in this study includes variables termed entry cohort and elapsed age. Findings with this model show

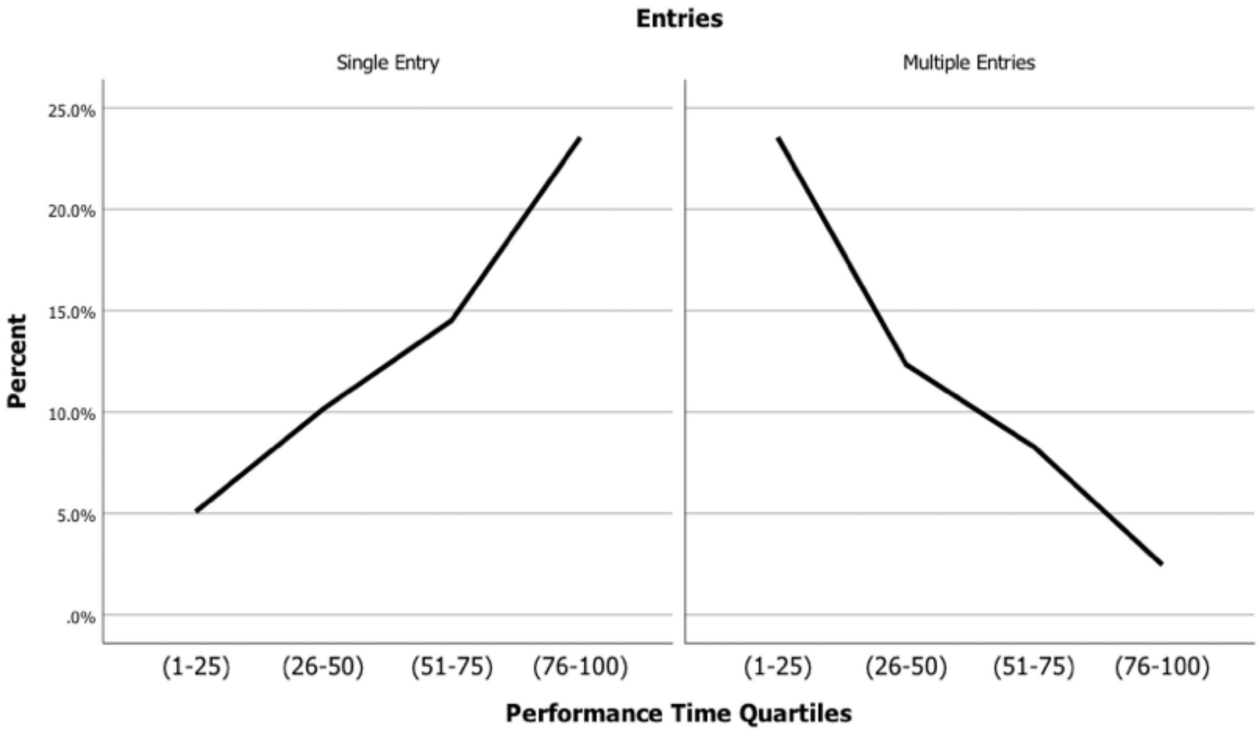

FIGURE 1 | Percent single and multiple data entries by performance quartiles.

the following: (1) higher performance times in women than men; (2) higher rates of increase in performance time at older cohort ages and elapsed ages; and (3) increases in performance time with interactions between cohort age and elapsed age, cohort age and gender, and elapsed age and gender (i.e., with greater increases in women than men). Also, increases in performance time with cohort age and elapsed age are higher in slower than faster performance quartiles, with athletes in the faster quartiles more likely to have multiple data entries and athletes in the slower quartiles single data entries.

The beginning of this article includes discussion of the methodology of early studies of age trends in performances by master athletes. Such methodology falls here under a rubric of the Concurrent Age model. This approach to modeling endures today – despite historical progress in the quality of available data and more sophisticated analytic procedures. Such models have relative simplicity that satisfies scientific requirements for parsimony but may fall short on requirements for scientific precision. Criteria for the latter combine data analytic premises that are reasonable (e.g., independence of athletes rather than observations) with high goodness of fit. This study may be the first to provide quantitative comparison of the Concurrent Age model against alternative models that decompose concurrent age into components that represent different temporal trends. It is also the first to examine the generalizability of cohort differences and age changes across levels of athletic performance.

The findings replicate earlier evidence that performance decline is greater at older ages and in women than men. As hypothesized, the Entry Cohort model provides better fit to the data than the Concurrent Age and Birth Cohort models. This finding provides justification to include entry cohort and age change terms in future research. Trends on both of these components exhibit greater rates of performance decline at older ages, with the declines steeper in women than men. Finally, the findings for both cohort differences and age changes support the hypothesis of greater performance decline in slower than faster runners.

The use of performance rankings to predict performance time is compatible with earlier research (Fairbrother, 2007). That study includes analysis of U.S. Masters Swimming's annual Top-Ten rankings for 50 m freestyle swimming. However, Fairbrother (2007) examines performance trends on concurrent age to derive inferences about generalizability from residual error. Inferences about generalizability in the present study follow from predicted scores for performance trends on entry cohort age and elapsed age. Despite these differences in methodology, the findings uniformly indicate shallower performance declines on the respective temporal dimensions by faster than slower athletes.

Moreover, analysis of the quartile rankings suggests reasons why the faster runners show shallower age declines. The fastest runners (1) are more likely to enter the database at a younger age than the slowest runners and (2) have a higher frequency of multiple data entries. An interpretation is that a combination of multiple entries by younger runners provide evidence for high levels commitment by these runners, which implies prolonged continuation of effective training practices, which in turn implies greater retention of faster racing times.

Consequently, information for coaches and master marathon runners might advisedly include planning for continued participation in order to realize and retain performance potential. Such planning could include competition against high performers in surrounding age classes, participation in races on faster courses, and extra commitment upon entry into a higher age class (Medic et al., 2009). The planning might also include adequate nutrition, sleep, and rest times in order to facilitate recovery from strenuous training and racing. Finally, coaches and master athletes might model their own practices on those of master athletes that demonstrably retain high levels of performance over prolonged historical periods.

Although the strengths of the study include analytic innovations applied to the most extensive database available on "best ever" marathon performances by master athletes, a concluding comment must also mention the study's limitations. Analysis of any such database can only be retrospective. Master athletes may exhibit high-level or low-level performances but assignment to such conditions cannot be by random assignment. Consequently, drawing causal inferences requires caution. Moreover, the database provides information mainly on performance times and demographics. It requires more exhaustive investigations to fully understand why and how some master athletes retain elite status over prolonged historical periods.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study is exempt from full review by the Research Ethics Board of Lakehead University because all the data analyzed are in the public domain.

AUTHOR CONTRIBUTIONS

MS analyzed the data and wrote the manuscript.

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frontiers in Psychology

BRIEF RESEARCH REPORT
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Trait Self-Control Discriminates Between Youth Football Players Selected and Not Selected for the German Talent Program: A Bayesian Analysis

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Trait self-control predicts success in various walks of life. Sports is a prototypical domain, where self-control is required, and there is evidence that successful athletes display superior self-control. Here, we assess if self-control already differs between athletes that were selected for a talent development program and non-selected athletes. Self-reported trait self-control was assessed in n = 25 (7 = female, 13.2 ± 1.7 years) youth football players who were part of the German talent development program and in n = 27 (6 = female, 13.6 ± 1.8 years) age and sex matched youth football players, who trained at the same clubs but had not been selected for the program. A one-sided Bayesian two-sample t-test yielded a Bayes factor of 54.99, indicating very strong evidence for the hypothesis that elite youth football players have higher trait self-control than non-elite youth football players. The 95% credibility interval indicates that the true value of δ lies between 0.28 and 1.42, indicating some uncertainty regarding the effects' magnitude. We show that already at young age, elite athletes display higher levels of self-control than their less successful peers. This underlines the importance of self-control as an important personality factor for success. These findings might have implications for talent selection and for sport psychological training.

Keywords: personality, football/soccer, talent, Bayes factor, expertise

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Sporting federations invest a lot of resources in finding talents that might later develop into world class athletes. For example, in their development program which is aimed at 11–14 year old children, the German football federation (Deutscher Fussball Bund; DFB) invests about ten million Euros per year with the stated goal to give every talent "the same chance to be scouted, developed, and sponsored (DFB, 2019b)." However, "it is hard, if not impossible, to identify future top performers at a very early age (Toering and Jordet, 2015, p.1)." The development of youth talent is affected by multiple genetic and environmental influences and inter-individual variation in physical maturation further reduces the predictive validity of talent identification programs (e.g., Vaeyens et al., 2008). Consequently, researchers have emphasized the need to focus more on the development of expertise (Toering and Jordet, 2015). Irrespective of the sporting discipline (or indeed any other domain), expertise development relies on deliberate practice (Ericsson et al., 1993). Indeed, the amount of deliberate practice athletes accumulate is linked to the level of expertise they achieve (Baker and Young, 2014; but see also Macnamara et al., 2016).

Training to become an elite athlete can take more than 20 years (Walsh, 2014), and the road to success might not be a linear one. In addition, dedication to training relies on effort and athletes have to delay more immediate gratifications (e.g., going out with friends) to achieve their long-term goal of becoming an elite athlete (Tedesqui and Young, 2017). Consequently, researchers have become interested in personality traits that might facilitate the accumulation of expertise in sports (e.g., Bartulovic et al., 2017; Tedesqui and Young, 2017). One such trait might be self-control. Self-control refers to the effortful regulation of spontaneous impulses in order to bring behavior in line with valuable goals (Duckworth, 2011). Self-control has been conceptualized as a state and a trait (Tangney et al., 2004). Research on state self-control has repeatedly shown that self-control affects performance in different sporting disciplines (for a review, please see Englert, 2016). For example, impaired performance has been found in sprint-running and time trial cycling if participants had performed a self-control demanding task before (Englert and Wolff, 2015; Englert et al., 2015). Thus, research on state self-control indicates that self-control is needed to perform a single bout of exercise at a high level, which might in the long run help in the attainment of expertise because the quality of deliberate practice might be enhanced. In addition, self-control has consistently been associated with successful goal-striving and the foregoing of immediate impulses in the service of a more important long-term goal in various domains (e.g., de Ridder et al., 2012; Mischel, 2014). For example, in a 32-year longitudinal study, Moffitt et al. (2011) showed that "childhood self-control predicts physical health, substance dependence, personal finances, and criminal offending outcomes (p. 2693)." Since achieving elite status in sport can also be seen as a challenging long-term goal, we assume trait self-control in youth athletes might be an important contributor to success too.

In regard to trait-self-control, research indicates that self-control might help athletes stick with work out regimes (e.g., Bertrams and Englert, 2013), facilitate the accumulation of deliberate practice (Tedesqui and Young, 2017), and in turn facilitate the attainment of greater levels of expertise (Toering and Jordet, 2015; but see also Tedesqui and Young, 2017). Thus, better athletes might be better at controlling themselves. In line with this, Martin et al. (2016) showed that elite cyclists performed better on a computerized stroop task than their non-elite counterparts. The stroop task is among the most frequently reaction-time based behavioral measures of self-control (Wolff et al., 2018) and has displayed convergent validity with self-report measures of self-control (Duckworth and Kern, 2011). Accordingly, in a study that utilized a self-report measure of trait self-control, Toering and Jordet (2015) found a small positive association between sports performance and self-control in a sample of adult Norwegian soccer players. Using a sample that was more heterogenous in regard to age and sporting discipline, Tedesqui and Young (2017) found a more complex pattern of results: the impulse control facet of self-control was linked to more voluntary practice time and athletes high in self-discipline (a second self-control facet that was analyzed by Tedesqui and Young) reported fewer thoughts of quitting their respective sports. However, differences in self-control were not linked to athletes' skill levels. Thus, while facets of self-control were linked to variables that contribute to attaining expertise, this was not accompanied by a higher athletic level. Taken together, while trait self-control appears to be important in the sporting context, further research is needed to better understand the exact relationship between high trait self-control, and athletic level (Tedesqui and Young, 2017).

For example, it is unclear if potential differences in trait self-control already exist in the youth ranks or whether differences emerge later as part of being an elite performer. Various studies have shown that already in their first decade of life, their levels trait self-control prospectively predict childrens' academic success (Vitaro et al., 2005; Moffitt et al., 2011; for an overview on the role of self-control in academic achievement, please see Duckworth et al., 2019). This suggests that individual differences in self-control are meaningfully associated with success already at a young age.

THE PRESENT STUDY

Across several domains, including sport, trait self-control is associated with favorable outcomes (e.g., de Ridder et al., 2012; Englert, 2016). Less is known if trait self-control differentiates between the successful and the less successful and if such differences are already manifest in youth athletes. However, in light of the difficulty of identifying talent (Vaeyens et al., 2008) it is crucial to investigate personality traits that might facilitate expertise development (Toering and Jordet, 2015; Tedesqui and Young, 2017). Here we set out to test this open question by assessing self-reported self-control in a sample of youth football players that have been selected for the German talent development program and a matched control group of football players from the same clubs. As self-control appears to differentiate the successful from the less successful students in school already at a young age, we expect a similar pattern in regard to sports performance. Thus, we tested the hypothesis that selected youth football players score higher on a standardized measure of trait self-control than youth football players from a control group.

METHODS

Participants and Procedure

Fifty-two youth football players (n = 13 female, M = 13.42 ± 1.75 years, range 11–17 years) from Southern Germany participated in the study. All players all came from the same Football district (Lake of Konstanz) and trained at one of four clubs within this district. Within their clubs, some players were either selected (n = 25) or not selected (n = 27) for the German talent development program. The German talent development program aims at identifying a region's biggest talents and supporting them to maximize their chances of becoming an elite level adult player. To do so, the DFB employs about 1.200 coaches to identify the most promising youth players that train in one of the 25.000 football clubs in Germany. Within

this large-scale approach, about 22.000 talented children and adolescents participate in the program annually[1]. To enhance the chance of being selected for the program, the children can train specific selection-relevant drills that are provided by the DFB as technical skills talents should possess to make it to the program (dfb.de). Talents that are selected for the program receive one extra training session per week by a coach that is appointed by the DFB (DFB, 2019b). After they and their caregivers had given written informed consent at the training facility, the youth athletes were provided with a link to an online questionnaire that consisted of a trait measure of self-control, and demographic variables. The questionnaire could then be completed at home by the players. The procedure followed the guidelines laid out in the Declaration of Helsinki.

Measures

Trait self-control was measured with the German version (Bertrams and Dickhäuser, 2009) of a well-established measure of self-control, the Brief Self-Control Scale (BSC; Tangney et al., 2004). The BSCS consists of 13 items that have to be answered on a 5-point Likert-type scale with answers ranging from "does not apply at all" to "applies completely." A sample item is for example "I am good at resisting temptation." High levels on the BSCS reflect higher trait self-control and total ω was = 0.82 in our sample.

Weekly training volume was assessed with one item, referring to the frequency of their weekly club training: "How many club training sessions do you have per week?" Answers could range between one and five times per week. A second question asked for the duration of each training session: "How long does a session last?" Based on typical training durations in this age group, the answering options 60, 75, 90, 105, or 120 min were provided. If none of those options were correct, players could also enter the duration in a text field. To arrive at weekly training load in minutes, frequency and duration were multiplied for each player.

Statistical Approach

Here, we use Bayesian inference as opposed to more traditional null-hypothesis significance testing (NHST). Recent years have seen an increase in the use of Bayesian inference (van Doorn et al., 2019) and a rising awareness of the limitations that are inherent to NHST (Kruschke et al., 2012). A Bayesian approach has multiple pragmatic advantages (Wagenmakers et al., 2018), such as the possibility to quantify evidence in favor of the null hypothesis (e.g., Dienes, 2014) and to compare statistical models (e.g., Wagenmakers, 2007). In spite of these advantages, Bayesian inference has not yet been adopted by many sport psychology researchers. Following recent calls (e.g., Kruschke et al., 2012) we applied Bayesian statistics. We employed easy to use open-source software (JASP; JASP Team, 2018) and we followed the recommendations laid out by van Doorn et al. (2019).

[1]For reference, in 2019, more than 1.8 million boys and more than 300.000 girls were listed as DFB members (DFB, 2019a).

RESULTS

Sample Characteristics

The Bayes factors for comparing the selected (M_{age} selected = 14.20, SD_{age} selected = 1.71) and non-selected groups (M_{age} non-selected = 14.63, SD_{age} non-selected = 1.80) provide no evidence for differences in regard to age (*Bayes factor* = 0.38) or sex (selected = 72% female, non-selected = 77.8% female, *Bayes factor* = 0.33). Expectedly, comparing the weekly training minutes of the selected group ($M_{training}$ selected = 262.8, $SD_{training}$ selected = 67.10) and the non-selected group ($M_{training}$ non-selected = 196.7, $SD_{training}$ non-selected = 60.05) provided very strong evidence for a higher training load in the selected group (Bayes factor = 59.79).

Inference Statistics

To test the hypothesis that elite athletes display higher levels of self-control than their non-elite peers, we performed a one-sided Bayesian two-sample *t*-test, and we report the Bayes factor to quantify evidence for this hypothesis (**Figure 1**). The Bayes factor obtained from this analysis is 54.99, indicating very strong evidence in favor of the hypothesis that elite youth football players indeed have higher trait self-control ($M = 3.75$, $SD \pm 0.47$) than non-elite youth football players ($M = 3.33$, $SD \pm 0.40$). As an estimate for the effect size and the uncertainty regarding its size, we report the 95% credible interval around the posterior distribution of the standardized effect size δ obtained from this *t*-test. The credible interval shows that, under the assumption that the effect exists, its true size is between 0.28 and 1.42. One frequent critique of Bayesian statistics is the subjectivity that can be introduced by the prior specification. We report the Bayes factor robustness test to assess how the Bayes factor would change if priors of different width had been chosen. As can be seen in **Figure 2**, the Bayes factor remained relatively stable across various prior specifications, indicating the robustness of our findings.

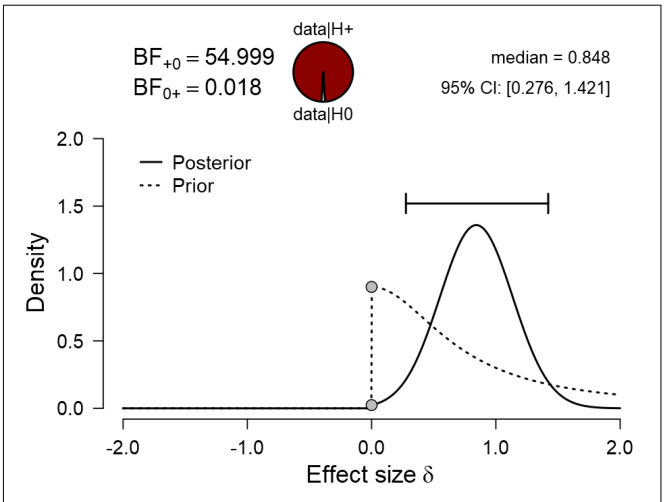

FIGURE 1 | Results of the Bayesian two-sample *t*-test.

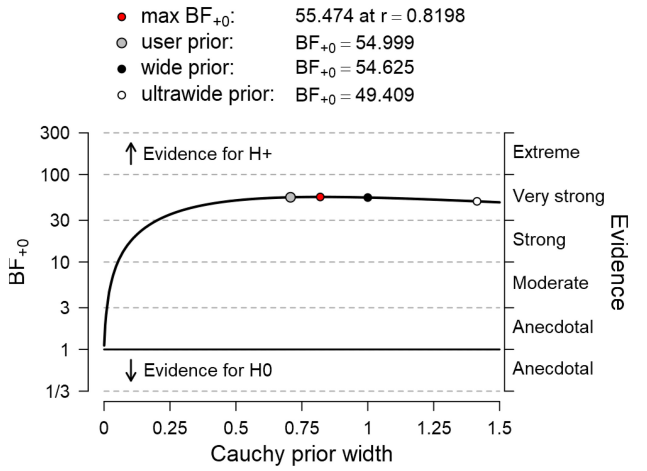

FIGURE 2 | The Bayes factor robustness test shows that the obtained results are relatively robust against different prior specifications.

DISCUSSION

We found that youth football players that were selected for a talent development program display higher levels of self-control than their non-selected peers. This extends previous research on the importance of self-control in sports by highlighting that self-control differences are evident already at a very young age. Further, our findings add to the emerging pattern that personality differences are important aspects of athletic success (Allen et al., 2013). More specifically, they add to the still relatively scarce body of literature that investigates the role of trait self-control in regard to athletic success (Toering and Jordet, 2015) and expertise development via deliberate practice (Tedesqui and Young, 2017).

One can think of two possible explanations for these findings. On the one hand, the sporting environment, with its emphasis on foregoing immediately gratifying activities (e.g., watching TV) and instead putting effort into activities that might not offer immediate gratification (e.g., going for an endurance run) but that make long-term success more likely, might affect trait self-control. Thus, more talented athletes might be more frequently exposed to self-control demanding situations and develop trait self-control as a consequence of their athletic involvement. According to this view, higher trait self-control is not a prerequisite for achieving elite level but rather a consequence of involvement in such demanding contexts. This is in line with research on the positive effect of childhood sports participation (for children as young as 6 years old) on positive personality development (e.g., Allen et al., 2015). In addition, research on the effectiveness of self-control training provides preliminary evidence that self-control can indeed be improved if people repeatedly apply self-control (for a meta-analysis, see Friese et al., 2017). However, it must be noted that the average effect size of these trainings is relatively small (Friese et al., 2017) and personality tends to be quite resistant to change, getting more stable as a function of age (Anusic and Schimmack, 2016). In line with this, it has been suggested that self-control is quite stable after the age of ten (Hirschi and Gottfredson, 2001; Turner and Piquero, 2002), which renders big improvements in self-control due to sports participation less likely.

On the other hand, due to the self-control demands that are imposed by the sporting environment, youth athletes with inferior self-control might simply be more likely to drop out of talent development programs because they might struggle to consistently invest the effort needed for keeping up with higher demands. In line with this, higher trait self-control is associated with reduced perceptions of mental effort in physically demanding tasks, indicating a more efficient management of self-control demands (Wolff et al., 2019a). This explanation also fits well with the proposition from expertise development that emphasizes the need for effortful deliberate practice (Ericsson et al., 1993) and the finding that better athletes indeed tend to have accumulated more deliberate practice (Baker and Young, 2014). After all, a highly competitive environment like elite sports requires youth athletes to refrain from attractive short-term goals (e.g., sleeping longer in the morning) and instead to invest effort toward their long-term goal (e.g., putting in an early morning training session before school). Thus, those who are better at investing and tolerating effort might simply be better equipped to stay in this environment. This is also in line with longitudinal research in the academic setting showing that self-control is a significant predictor for academic success (e.g., Duckworth et al., 2019) and that self-control is linked to better exercise adherence (e.g., Stork et al., 2017).

Limitations and Future Research

Taken together, our study indicates that selected and non-selected youth football players differ in regard to trait self-control. However, it has yet to be investigated what this difference means, as our study was not designed to test the validity of either of the explanations described above. Further, both explanations must not be mutually exclusive: While it appears likely that self-control helps youth athletes to reach elite status, it cannot be ruled out that the sporting environment further strengthens trait self-control. To unravel how self-control and the development of elite athletic level are related, cross-sectional studies do not suffice. Since experimental studies are not suitable for the investigation of this relationship, only longitudinal designs remain, which are carried out with sufficiently large samples of elite youth athletes over extended periods of time, so that sophisticated statistical methods can be applied (Duckworth et al., 2010). The present finding can be understood as an indication that such extensive and costly research may be worthwhile. Such future research, which also addresses the underlying processes, could help to further optimize the promotion, selection, and training of elite athletes.

Second, although research points toward trait self-control as being an important individual difference variable for athletic success (Toering and Jordet, 2015; Martin et al., 2016), this has not been found in all published studies. For example, although they found a relationship between trait self-control and deliberate

practice variables, Tedesqui and Young (2017) did not find differences in self-control variables between more or less skilled athletes. While it is difficult to make comparisons across studies, two differences between the present study and the study by Tedesqui and Young (2017) are obvious and might provide an impetus for further research. First, the sample of Tedesqui and Young was composed of athletes who were from different sports and primarily from individual sports (68.8%) as opposed to our football-only sample. Future research might directly focus on assessing differences between individual and team sports or differences between skill-based and more endurance determined sports to understand if the role of trait self-control varies between sports. Second, other researchers have utilized the BSCS to capture two factors of self-control (Toering and Jordet, 2015; Tedesqui and Young, 2017), whereas we chose to use the one-factorial solution. While there is research suggesting that the BSCS indeed captures two distinct facets of self-control (e.g., Maloney et al., 2012), a study on the factorial structure of the German variant did not find support for this two-factorial solution and the authors recommended using the unimodal score instead (Lindner et al., 2015). Thus, the potential dimensionality of trait self-control and its associated measures should also be a target for future research to establish if possible facets of trait self-control are differentially related with athletic success. In addition, researchers have focused on the positive effects of self-control (e.g., Moffitt et al., 2011) and generally high-self-control is held in high regard (Duckworth, 2011). However, since the exertion of self-control induces fatigue and feelings of frustration (Wolff et al., 2019b), one cannot rule out that the need to chronically employ self-control to stay in a highly competitive system like elite sports might negatively affect motivational and emotional states of youth athletes.

Taken together, while the initial evidence regarding the importance of trait self-control for athletic success is promising, it is clear that further research is needed to better understand the specific role of self-control on sporting excellence.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

The procedure followed the guidelines laid out in the Declaration of Helsinki (1975). Participation was voluntary and happend only after participants and their caregivers had given prior written informed consent. The present study falls outside the range of research requiring an IRB statement according to the position of the ethics committe of the University of Konstanz which states (https://www.uni-konstanz.de/en/university/administration-and-organisation/university-bodies-and-committees/university-bodies-for-scientific-integrity/ethics-committee/): "The Ethics Committee does not address questions (...), which do not affect the health, dignity or personal rights of human test subjects." This is the case for the present study as participants were not subjected to any experimental manipulation and only completed an anonymous questionnaire.

AUTHOR CONTRIBUTIONS

WW conceived the study design and discussed it with AB and JS, conducted the study and performed the statistical analyses, and wrote the first draft of the manuscript. AB and JS revised and finalized the manuscript.

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Getting to First Base: Developmental Trajectories of Major League Baseball Players

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The road to professional baseball illustrates the complexity, variability and non-linearity of athlete development, as players may be drafted from various high school, 2 year, or 4 year programs and then placed into extensive minor league systems. The purpose of this study was to identify the different pathways to Major League Baseball (MLB) and explore their influence on career success. Performance and developmental data of 2,291 American-born MLB players who debuted between 1990 and 2010 were collected using baseball-reference.com. Three performance indicators, career games played (GP), age of debut, and wins above replacement (WAR; player's total contributions in wins), were coupled with high school, post-secondary, and Minor League Baseball (MiLB) data. Analyses revealed 17 descriptively different pathways to MLB, which were grouped into three main streams based on the last institution attended before entrance into professional baseball. Overall, 63% of the athletes started their career directly after attending a 4 year higher education institution, 23% after high school, and 14% directly after attending a 2 year institution. Interestingly, 78% of the athletes did not sign or were not selected as high school draft picks. Position players drafted or signed from high school debuted in MLB younger (M = 23.99) and averaged significantly more MiLB GP (M = 909.13) than those drafted or signed from a 2 year (M = 25.67 and 834.41 GP) or 4 year institution (M = 25.95 and 752.33 GP). Pitchers signed or drafted from high school also debuted in MLB younger and played more MiLB games, as well as played in more MLB games than players from a 2 year or 4 year institution, $F(8, 3{,}082) = 31.96$, $p \leq 0.001$. No significant differences of WAR were noted in position players or pitchers. Perhaps pitchers who are drafted from high school are afforded more opportunities to succeed, which may be indicative of sunk cost effects. This is conceivable as these players had the highest average GP but did not accrue a higher WAR. Future research may benefit from the consideration of post-secondary and/or high school statistics in combination with draft selection data, which may have important implications for improving talent identification accuracy.

Keywords: pathways, high performance, sport, talent identification, athlete development

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INTRODUCTION

The sporting entry draft and the ability (or lack thereof) of professional front offices to successfully identify high-caliber players is well researched (Simpson, 1990; Staw and Hoang, 1995; Spurr, 2000; Popper, 2004; Koz et al., 2012). One of the challenges of navigating elite sport entry drafts is that athletes may enter the draft having experienced different athlete development contexts and may have taken different pathways within those contexts. This complicates decisions and judgments about talent and potential, and may be a constraint for Major League Baseball (MLB) in particular. Analyses of MLB's first-year player draft often yields results that are significantly different from the three other major North American sports (National Football League – NFL, National Basketball Association – NBA, National Hockey League – NHL). Koz et al. (2012) demonstrated this when the relationship between career games played (GP) and draft round were explored across MLB, NBA, NHL, and NFL. Unlike the three other sports, no significant differences were found between draft rounds and GP in MLB. Of course, the ideal drafting strategy would be to use early round draft picks to select players with the best potential for performance (career GP) as the cost for these selections (in terms of contracts and bonuses), compared to late round selections, is much higher (Massey and Thaler, 2013). However, this strategy appears to be extremely difficult to implement in the MLB market. In fact, a study of first round draftees selected between 1965 and 1985 found that only 63% of those players played even one game at the major league level (Spurr, 2000).

An obstacle that MLB front offices face is consolidating the abundance of information on developing baseball players. The explosion of "sabermetrics," a term coined by Bill James to explain the analysis of performance data via detailed statistics (see Beneventano et al., 2012; Costa et al., 2014, for extensive reviews and background information) has revolutionized how professional clubs interpret the efficiency of players. However, the lack of verifiability in performance statistics from the different player development pathways (e.g., collegiate vs. high school levels) largely restricts sabermetrics to analyzing players already in MLB. Moreover, the quality of different athlete development contexts and pathways may make it difficult to appraise an athlete's skill level and potential. As such, there is a need for research that explores the influence of variation in pathways to elite sport.

Research dedicated to describing optimal sport participation and athlete development pathways typically focuses on youth sport and appropriate *types* of participation. These trajectories and stages typically focus on the optimal and sub-optimal (according to their proponents) qualitative and quantitative characteristics of sport participation. In a model like the Developmental Model of Sport Participation (DMSP; Côté et al., 2007; Fraser-Thomas and Côté, 2009), these characteristics include whether athletes participate in one sport or multiple, the focus on play and intrinsic motivation, the focus on effortful practice (deliberate practice), and at what ages these activities occur. Similarly, the Foundation, Talent, Elite, Master (FTEM) model describes a number of stages (see Gulbin J.P. et al., 2013; Weissensteiner, 2015): foundational (i.e., learning and refining basic movement skills, and eventual commitment to sport), talent (i.e., demonstration and verification of talent, and initial success and reward for performance), elite (achievement of status and success at elite/professional levels), and mastery (success over multiple years). Like the DMSP, each stage is also associated with "best practices" or ideal characteristics (Weissensteiner, 2015). In some ways, such models attempt to summarize higher order themes and stages in order to be as generalizable as possible.

One of the challenges to such models is accounting for the fact that there can be notable variation in the pathways and opportunities *within* the stages described in many athlete development models. Whether it is the "pre-elite" phase of the FTEM, the "training to compete stage" of long-term athlete development (LTAD), or the "investment years" stage of the DMSP, these models and phases do not account for the significant variation in the contexts that athletes may be participating in. For example, in each of the aforementioned stages, an athlete could be participating in an elite amateur developmental league, in university/college sport, or within club system. Indeed, it is not clear how variations in *the contexts in which* athletes participate during certain stages of athlete development influence the likelihood of future success in elite sport.

The road to MLB, with the various collegiate programs across North America and its extensive minor league system, is an excellent illustration of the potential importance different pathways have on athlete development. High school baseball players who go undrafted often have to choose between 2 year and 4 year institutions whilst balancing the opportunity for playing time and national exposure. Two year institutions include both junior and community colleges where student athletes can compete for two seasons and/or two academic years. Often, these institutions are used as a stepping stone between high school and a 4 year institution or a professional career. Four year institutions include colleges and universities that offer 4 years of athletic eligibility, where students complete courses to earn bachelor's degrees. Players drafted out of high school must decide between signing a professional contract or furthering their development at a collegiate program to increase their stock in future drafts. Namely, if they are satisfied with the round they were drafted in and/or the contract, they will sign. Conversely, players who are unsatisfied with their perceived value will decline the contract with the hope that more training will lead to a higher selection in future drafts and thus a more substantial contract. If the athlete chooses to sign the professional contract, they still must traverse the many levels of Minor League Baseball. Although high school aged athletes and their families encounter these challenging decisions every year, research has yet to explore the relationship between specific pathways and later career success. Literature often focuses on the sporting pathway that may develop professional players (Ginsburg et al., 2014) or the capability of professional leagues to successfully identify these players, but rarely does it focus on the relationship between the two. Spurr (2000) and Arnette (2014) attempted to analyze this relationship. The former based success on a player participating in one MLB game and sought to determine the influence that position played, draft round, and highest level of education

attained may have on such success. This study largely focused on the ability to identify talent and did not attempt to analyze career success at the MLB level. Arnette (2014) compared the performance of position players (i.e., infielders, outfielders, and catchers) drafted from high school to the performance of players drafted from National Collegiate Athletic Association (NCAA) institutions. Performance was quantified with baseball's on-base plus slugging (OPS) metric and pitchers were excluded from analyses. Although these studies were important to the talent identification field, they do not assess the significant variability in each pathway and/or include modern performance indicators.

The purpose of this study was to explore the different pathways to MLB and their influence on career success. To achieve a granular description of post-high school pathways, an exploratory approach was used to document all possible pathways to MLB. Once established, we quantitatively assessed the commonality of these pathways in a substantial sample and assessed their effect on career success using modern performance indicators.

MATERIALS AND METHODS

Sample

Our sample consisted of American-born professional baseball players who registered at least one MLB game played between the 1990 and 2010 seasons (N = 2, 291). Players were included if their professional debut occurred after April 9th, 1990 (opening day of the 1990 season) and their last professional appearance occurred before November 1st, 2010 (final game of the 2010 season). These dates were selected to establish a 20 year window as research suggests the average career length of an MLB position player is 5.6 years (Witnauer et al., 2007). Thus, a window of 20 years allows the average career player to turn over almost 4 times. Additionally, these specific dates were selected to ensure that all players were truly retired yet still participated in an era fairly representative of modern baseball strategy and evaluation. All players who were not born in the United States of America and/or never registered one game played, were excluded from this sample. For example, American-born players who may have been drafted by a professional baseball team but never registered one official game played in MLB were excluded.

Data were collected from www.baseball-reference.com using player IDs that were collated in a previous dataset (Lemez et al., 2016). Each player ID was entered into Baseball-reference's search engine allowing compilation of career information and statistics. To ensure the validity of these data, we compared values to additional online sources of baseball information such as www.thebaseballcube.com, www.mlb.com, and www.fangraphs.com. Complete agreement was found amongst each website for draft and career statistics with the exception of Wins Above Replacement (Baseball Prospectus and FanGraphs have their own variations of this metric that differ in the weighting of certain statistics). Pathway information, such as competing at a 2 year or 4 year institution, was verified via the official athletics webpage of the corresponding institution.

Performance Metrics

Three performance indicators, age of MLB debut, career GP, and Baseball-Reference's Wins Above Replacement (bWAR) were collected to quantify success. Younger age of debut may be an indication of precocious performance and/or talent (MLB age of debut was computed using date of birth and date of first MLB game). Intuitively, the number of games a player participates in at the professional level is an adequate representation of their career success. This is particularly true for MLB as it drafts the most players and has the most extensive developmental system of the four major North American sports. For example, 32,237 athletes were drafted into MLB between the 1990 and 2010 seasons (Baseball-Almanac, 2019; MyMLBdraft.com, 2019). In the same time frame, 5,490 and 5,345 players were drafted into the NFL and NHL, respectively (Hockey-reference, 2019; Thefootballdb, 2019). This does not include athletes who signed as undrafted free agents, nor does it capture the difficulty of being drafted. Thus, the efficacy of using career GP to indicate career success stems from the immense competition pool traditionally seen in MLB where only the best participate.

To clearly illustrate the value of the athletes to their respective teams, we needed to supplement GP with an additional metric that quantified in-game performance. This was accomplished with bWAR. Simply put, bWAR is www.baseball-reference.com's adaptation of a measurement that compares the value of a player relative to the value of a replacement level player that may be available (Baseball-reference, 2019b). This measurement is calculated on an interval scale where a positive number demonstrates that a player is contributing to more wins than a replacement level player, hence Wins Above Replacement. For instance, as of the conclusion of the 2018 season, Albert Pujols possesses the highest active bWAR with 100 (Baseball-reference, 2019a). This suggests that Pujols has contributed, in comparison to an average player, 100 more wins to his team throughout his career. While bWAR does not have the traditional appeal that batting average and earned run average provide, it is one of the only statistics that accounts for multifaceted performance (i.e., hitting, defense, pitching, and base running). Furthermore, the possibility of achieving a negative bWAR (i.e., a player contributes less to wins than a replacement level player) ensures that this statistic is not heavily cofounded by the number of GP.

Pathway

Pre-draft data were used to descriptively delineate the different developmental pathways that athletes in this sample experienced before their MLB debut. Pathways were modeled around transfers between post-secondary institutions (i.e., transferring from a 2 year institution to a 4 year institution) and the decision to sign with a team once drafted (MLB allows you to be drafted multiple times).

Minor League Baseball (MiLB) GP were also collected at three levels to reflect time spent in the MLB's developmental leagues. This developmental system is traditionally structured so that a player is drafted and/or signed and placed in an "A" league. As a player gains experience and performs, they typically progress to "AA" and "AAA" leagues. Although this is the format of the developmental system, MLB teams may assign a player under

contract to any league they choose. Also, a player may be demoted or promoted between leagues at the discretion of the MLB team that has contracted them.

Analyses

Pathways

Descriptive statistics were used to summarize each of the different pathways to MLB. The number of athletes, as well as average (and standard deviation) GP and bWAR within each pathway, were computed. Once descriptive statistics were generated, the data were inspected to determine if there were opportunities to dummy code pathways for the purpose of statistical analyses.

Pathway and MLB Performance

All analyses of career performance were performed separately for pitchers and position players because pitchers typically accrue MLB GP at a much slower rate than position players. For instance, Brad Ziegler had the most regular season MLB GP by a pitcher in 2018 with 82. Comparatively, seven position players earned 162 MLB GP in 2018 (i.e., they played in every game of the regular season). One-way MANOVAs were performed to test if the last institution attended influenced athlete's professional performance or the route to MLB. MLB GP and bWAR, MiLB GP, and MLB debut age were used as dependent variables. The last institution attended (i.e., high school, 2 year institution, or 4 year institution) was the independent variable. To determine the significance of these multivariate tests, Pillai's criterion (Norman and Streiner, 2008) and Tukey's Honest Significant Difference (HSD) tests were used for *post hoc* analyses.

Pathway and Minor League Baseball Trajectory

Beyond the athlete's performance at the MLB level, we wanted to determine if the last institution affected the trajectory in MiLB. To do this, another one-way MANOVA was run with "last institution" as the independent factor with A, AA, and AAA GP used as the dependent variables. Pillai's criterion and Tukey's HSD were again used to determine significant differences between the pathways. Furthermore, simple linear regressions were calculated to quantify the relationship between MLB GP and bWAR based on the amount of GP at each MiLB level (A, AA, and AAA). Standardized Beta Coefficients are reported to depict these models.

Pathway and Variation in MLB Career Performance

To understand what could lead to variation in MLB success, players were grouped depending on their percentile ranking in performance. Frequency analyses were conducted so that position players and pitchers were coded as top 20%, middle 60%, or bottom 20% in MLB GP. A chi-square test of independence was performed to examine the relationship between last institution attended and MLB GP tier (i.e., top, middle, and bottom). Additionally, one-way MANOVAs were conducted for position players and pitchers with MLB GP tier identified as the independent factor and bWAR, MiLB GP, and MLB debut age used at the dependent variables. Significant differences between the dependent variables were determined using Pillai's criterion and Tukey's HSD further assessed these differences.

Analyses were performed using SPSS version 25, and statistical significance was defined as $p < 0.05$, at the 95% Confidence Interval (CI).

RESULTS

Pathway Grouping

Seventeen descriptively different pathways to MLB were identified (see **Figure 1**). Pathways were identified post-data collection. The drafting or non-drafting of an athlete from an institution was a key differentiator between pathways, as well as the choice to accept or turn down the draft. Of the 17 different pathways, five represented approximately 83% of MLB players in this sample (see **Table 1**). To manage the number of different groups for statistical analyses, pathways were then categorized into one of three main streams. These categories were determined by last institution attended and identified as high school, 2 year institution, and 4 year institution. Namely, players were sorted by the last institution attended directly before signing a professional MLB contract. This was selected as a common theme as every player in the sample began their professional baseball career after attending at least one of these three main institutions.

Pathway and MLB Performance

Position Players

A significant difference in MLB debut age ($p < 0.001$, $\eta_p^2 = 0.13$) and the amount of MiLB GP ($p < 0.001$, $\eta_p^2 = 0.04$) based on last institution attended, $F(8, 1{,}480) = 28.61$, $p < 0.001$; V = 0.27, $\eta_p^2 = 0.13$ (see **Table 2**) was observed. No significant differences between MLB GP and bWAR were noted. *Post hoc* analyses suggested that high school position players debuted younger and played in more MiLB games than position players from 2 year and 4 year institutions (see **Table 2**).

Pitchers

Pitchers also demonstrated a significant difference in MLB debut age ($p < 0.001$, $\eta_p^2 = 0.13$) and MiLB GP ($p < 0.01$, $\eta_p^2 = 0.01$) as well as in MLB GP ($p < 0.05$, $\eta_p^2 = 0.01$) based on last institution attended, $F(8, 3{,}082) = 31.96$, $p < 0.001$; V = 0.15, $\eta_p^2 = 0.08$ (see **Table 3**). *Post hoc* analyses revealed the same trend for pitchers as was seen in position players (younger MLB debut and more MiLB GP) but also showed that high school pitchers averaged more MLB GP than pitchers from a 4 year institution (see **Table 3**).

Pathway and Minor League Baseball Trajectory

Position Players

Position players demonstrated notably different MiLB trajectories based on the last institution attended. Specifically, "AA" ($p < 0.001$, $\eta_p^2 = 0.02$) and "A" ($p < 0.001$, $\eta_p^2 = 0.20$) GP differed significantly as a function of last institution attended $F(6, 1{,}482) = 29.86$, $p < 0.001$; V = 0.22, $\eta_p^2 = 0.11$ (see **Figure 2**). High school position players played significantly more

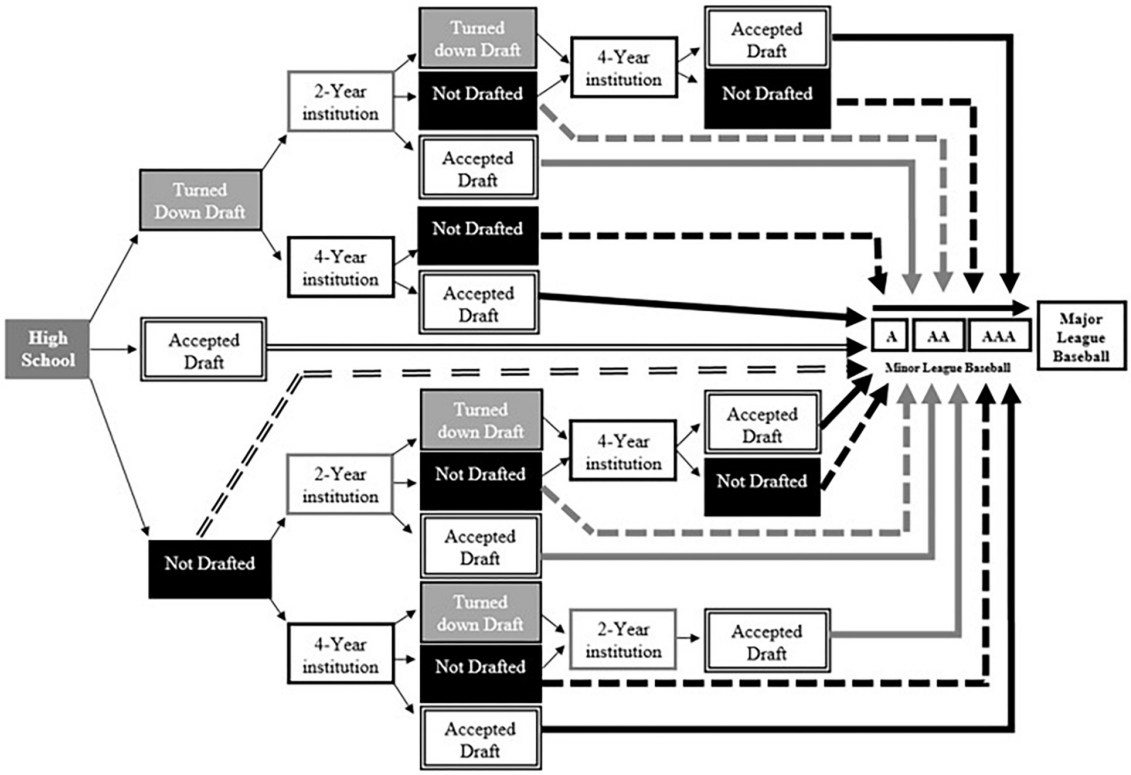

FIGURE 1 | Schematic illustration of the developmental pathways to MLB. Solid arrows represent players signing after being drafted whereas dashed arrows represent players signing as undrafted free agents. Degree of shading and design of arrow pointing to Minor League Baseball represents last institution attended. Single black line = 4 year institution, single gray line = 2 year institution, and double black line = high school. Not Drafted = players were not selected in the draft by a professional team. Turned down Draft = players were selected in the draft by a professional team but elected to turn down the contract associated with their selection. All players are draft eligible after high school graduation, and players at 4 year institutions are draft eligible 3 years after enrolling or after their 21st birthday.

"A" games than both 2 year and 4 year players. Additionally, they played significantly more "AA" and total MiLB games than players who were selected or signed after attending a 4 year institution (see **Figure 2**). No significant differences were noted at the "AAA" level.

Regression analyses revealed a statistically significant negative relationship between number of GP at AAA and AA MiLB and subsequent MLB GP for high school, 2 year, and 4 year pathway athletes. In addition, there was a statistically significant negative relationship between GP at A MiLB and MLB GP for 4 year pathway athletes (see **Figure 2**). The same results were found for the 2 year pathway, however, the relationship between GP at A MiLB and MLB GP was not statistically significant (**Figure 2**). Overall, more GP in MiLB is related to fewer MLB GP. The analyses between GP at AAA, AA and A MiLB and subsequent MLB WAR also demonstrated a negative relationship. With the exception of A-level GP for the 2 year pathway, this negative relationship was statistically significant for each pathway and each level of MiLB. The magnitude of this relationship was largest for AAA MiLB GP and MLB GP, and similar in size for each pathway (β range: −0.32 to −0.36). Like GP, the more GP in MiLB the lower WAR score in MLB.

Pitchers

Pitchers participated in significantly different AA ($p = 0.01$, $\eta_p^2 = 0.01$), A ($p < 0.001$, $\eta_p^2 = 0.06$) and total MiLB GP ($p < 0.01$, $\eta_p^2 = 0.01$) based on last institution attended $F(6, 3{,}084) = 26.85$, $p < 0.001$; V = 0.10, $\eta_p^2 = 0.05$ (see **Figure 3**). High school pitchers played significantly more A and AA games than pitchers from a 2 year institution and significantly more A, AA, and total MiLB games than 4 year pitchers. No significant differences were noted at the AAA level.

There was a consistent, and statistically significant, *positive* relationship between GP at A MiLB and MLB GP for each of the three pathways. The magnitude of this relationship was largest for high-school (0.35) and 2 year (0.38) pathways. In contrast, there was a negative relationship between GP at AAA MiLB and MLB GP (only statistically significant for the high-school and 4 year pathways). With respect to MLB WAR, there were no consistent patterns. For those emerging directly from high-school, there was a positive relationship between GP at AAA and MLB WAR, but a negative relationship between GP at A and MLB WAR (both statistically significant). For athletes emerging from the 2 year pathway, there were statistically significant negative relationships between GP at AAA and AA MiLB, and MLB WAR, while there was a

TABLE 1 | General pathways and their MLB performance.

Pathway	Description	Athletes (N)	MLB	
			GP *M* (*SD*)	bWAR *M* (*SD*)
1	High school draft → 4 year draft	334	233.8 (385.3)	2.5 (8.3)
2	High school draft	512	261.4 (418.4)	2.5 (7.2)
3	2 year draft	189	198.1 (341.7)	1.9 (6)
4	4 year draft	740	211.9 (363)	2.1 (7.2)
5	2 year draft → 4 year draft	116	194.7 (301.8)	1.6 (4.7)
6	High school draft → 4 year NO draft	14	320.2 (627.9)	2.1 (5.3)
7	2 year draft → 4 year NO draft	19	199.7 (348.9)	1.3 (3.6)
8	High school draft → 2 year draft	60	223.4 (391.1)	2.1 (6)
9	2 year NO draft → 4 year draft	102	172.5 (263.5)	2.1 (5.9)
10	High school draft → 2 year draft → 4 year draft	42	139.5 (247.2)	1.1 (4.5)
11	4 year draft → 2 Year draft	9	341.7 (246.2)	6.6 (5.4)
12	NO draft 4 year	58	132.9 (292.6)	1 (3.9)
13	NO draft 2 year	15	161.9 (221.1)	1.6 (5.5)
14	NO draft high school	21	155.9 (156.5)	0.7 (3.1)
15	High school draft → 2 year NO draft	30	161.2 (224.5)	1.4 (3.6)
16	4 year NO draft → 2 year draft	4	811.8 (871)	17.2 (28.4)
17	2 year NO draft → NO 4 year draft	26	179.7 (330.2)	2.2 (4.6)
	Total	2291	219.6 (368.9)	2.2 (7)

High school, high school institution; 2 year, 2 year institution; 4 year, 4 year institution; MLB, Major League Baseball; GP, Games Played; bWAR, Baseball Reference's Wins Above Replacement. → Indicates a transfer between institutions. Pathways that end in NO Draft suggest that the player signed as an undrafted free agent; M, mean; SD, standard deviation.

positive relationship between GP at A MiLB and MLB WAR (statistically significant). The 4 year pathway demonstrated the same relationship as the 2 year pathway, although only the AAA and AA GP demonstrated statistically significant relationships with MLB WAR.

Pathway and Variation in MLB Career Performance

Position Players

Chi-square results of position players suggested that last institution attended was evenly distributed across each tier of MLB GP, $\chi^2(4, N = 745) = 3.88$, $p = 0.42$, $\varphi_c = 0.05$. However, significant differences in bWAR ($p < 0.001$, $\eta_p^2 = 0.31$), MiLB GP ($p < 0.001$, $\eta_p^2 = 0.08$) and MLB debut age ($p < 0.001$, $\eta_p^2 = 0.08$) when grouped by tier of MLB GP, $F(6, 1{,}470) = 53.56$, $p < 0.001$; V = 0.36, $\eta_p^2 = 0.18$ (see **Figure 4**) were noted. Position players who finished in the top 20% of MLB GP averaged a higher bWAR, played significantly fewer MiLB GP, and debuted in the MLB at a younger age than players that finished in the middle 60% and bottom 20%. Additional analyses revealed that position players who finished in the top 20% of MLB GP played significantly fewer games at every minor league level, $F(6, 1{,}482) = 34.58$, $p < 0.001$; V = 0.25, $\eta_p^2 = 0.12$ (see **Figure 4**).

Pitchers

Unlike position players, chi-square results of pitchers suggested that last institution attended was not evenly distributed across each tier of MLB GP, $\chi^2(4, N = 1546) = 10.82$, $p < 0.05$, $\varphi_c = 0.06$. The asymmetry in distribution stems from the underrepresentation of 2 year players and overrepresentation of 4 year players, relative to expected counts, in the bottom 20% of MLB GP. Although this value was statistically significant, the low Cramer's V suggests that practical significance is lacking. Pitchers also demonstrated significant differences in bWAR ($p < 0.001$, $\eta_p^2 = 0.21$), MiLB GP ($p < 0.001$, $\eta_p^2 = 0.03$), and MLB debut age ($p < 0.001$, $\eta_p^2 = 0.04$) when grouped by tier of MLB GP, $F(6, 3{,}072) = 88.04$, $p < 0.001$; V = 0.29, $\eta_p^2 = 0.15$ (see **Figure 5**). Similar to position players, pitchers who finished in the top 20% of MLB GP averaged a higher bWAR and debuted in the MLB at a younger age when compared to the middle 60% and bottom 20%. However, pitchers were different from position players in that the top 20% averaged significantly more MiLB GP. In fact, pitchers who finished in the top 20% of MLB GP played significantly *more* games at every minor league level, $F(6, 3{,}084) = 21.02$, $p < 0.001$; V = 0.08, $\eta_p^2 = 0.04$ (see **Figure 5**).

DISCUSSION

The purpose of this study was to explore the variation in pathways to MLB, and assess their influence on career performance. We observed 17 independent pathways, spanning from being drafted out of high-school to attending a 4 year college, then participating in MiLB, before ultimately reaching MLB (with varying degrees of success). This variation is certainly consistent with the notion that pathways to elite levels of performance are rarely straightforward or linear (Gulbin J. et al., 2013). However, the current results also stress the need to consider how variations in *the contexts in which* athletes participate during the same, or similar, stages can have ambiguous influences on athlete development. The 17 pathways were sorted into three main categories based on last institution attended before entering professional baseball. Overall, there were asymmetries in the proportion of athletes from distinct athlete development pathways. Consistent with past research (Spurr, 2000), more players were drafted out of college; approximately 77% of players in the sample attended a post-secondary institution and were directly drafted or signed from there.

With respect to the different pathways, high-school-drafted pitchers and position players played significantly more games in MiLB, particularly at the A level. This suggests that A-level MiLB may be somewhat equivalent to college/university baseball with respect to competition and training quality. Alternatively, the characteristics of the athletes at this stage in their development (e.g., growth, maturation, skill, and/or ability) may align favorably with the characteristics of both MiLB-A and college/university (Hoffman et al., 2009). Interestingly, no

TABLE 2 | MLB and MiLB descriptive statistics – position players.

Last institution attended	Athletes (N)	MLB GP *M* (*SD*)	bWAR *M* (*SD*)	MiLB GP *M* (*SD*)	MLB debut age *M* (*SD*)
High school	170	326.82 (483.55)	2.44 (6.71)	909.13** (350.83)	23.99** (2.11)
2 year	87	304.79 (412.61)	2.09 (6.26)	834.41 (292.35)	25.67 (2.02)
4 year	488	278.36 (408.38)	1.85 (5.56)	752.33 (307.2)	25.95 (2.24)

*MLB, Major League Baseball; GP, Games Played; bWAR, Baseball Reference's Wins Above Replacement; MiLB, Minor League Baseball; M, mean; SD, standard deviation; N, number; **p < 0.01.*

TABLE 3 | MLB and MiLB descriptive statistics – pitchers.

Last institution Attended	Athletes (N)	MLB GP *M* (*SD*)	bWAR *M* (*SD*)	MiLB GP *M* (*SD*)	MLB debut age *M* (*SD*)
High school	363	224.67* (369.53)	2.47 (7.32)	366.43** (289.07)	23.80*** (1.90)
2 year	220	172.32 (316.24)	2.23 (6.80)	331.41 (240.69)	25.10 (2.09)
4 year	963	172.10 (319.07)	2.21 (7.56)	316.15 (257.30)	25.62 (1.91)

*MLB, Major League Baseball; GP, Games Played; bWAR, Baseball Reference's Wins Above Replacement; MiLB, Minor League Baseball; M, mean; SD, standard deviation; N, number; *p < 0.05, **p < 0.01, ***p < 0.001.*

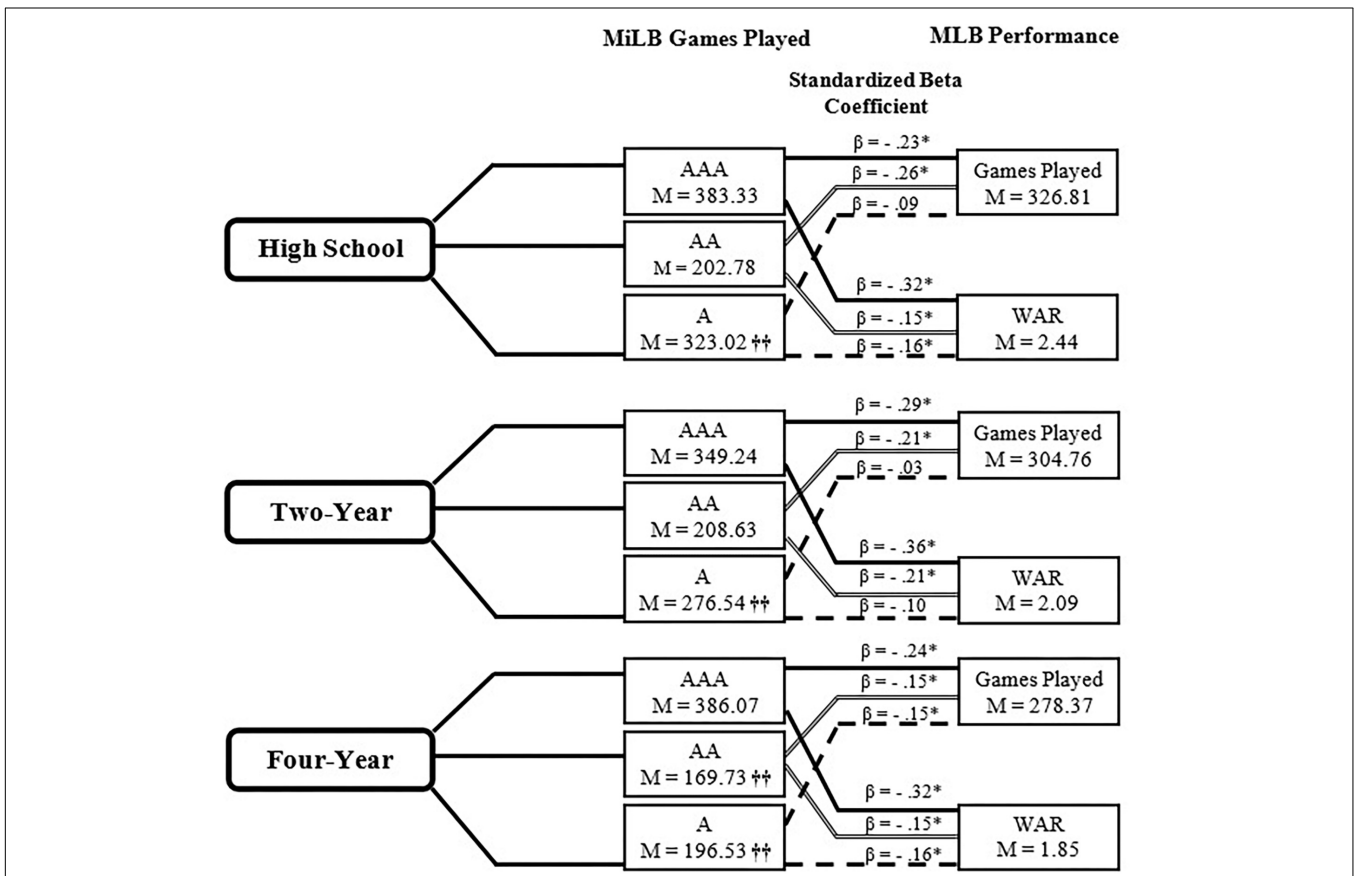

FIGURE 2 | Relationship between Minor League career and MLB performance- Position Players. WAR, Wins Above Replacement. ††Significant difference ($p < 0.05$) from two other institutions at that level. β Signifies standardized beta coefficient from regression model with A, AA, AAA Games Played used as predictors of Major League Baseball Games Played and Wins Above Replacement; *$p < 0.05$.

significant differences between the three pathways were noted in the amount of GP at the "AAA" level. This may be indicative of a "wash-out" effect of last institution attended in the minor leagues. Once the players reach the AAA level, it seems like the past baseball experiences of these players level off. However, the finding that high-school-drafted athletes were found to debut in MLB at significantly younger ages than athletes from the college/university pathways suggests that the trade-off, or equivalency, might not be exact. This may be due to several factors. Athletes drafted out of high-school may be viewed

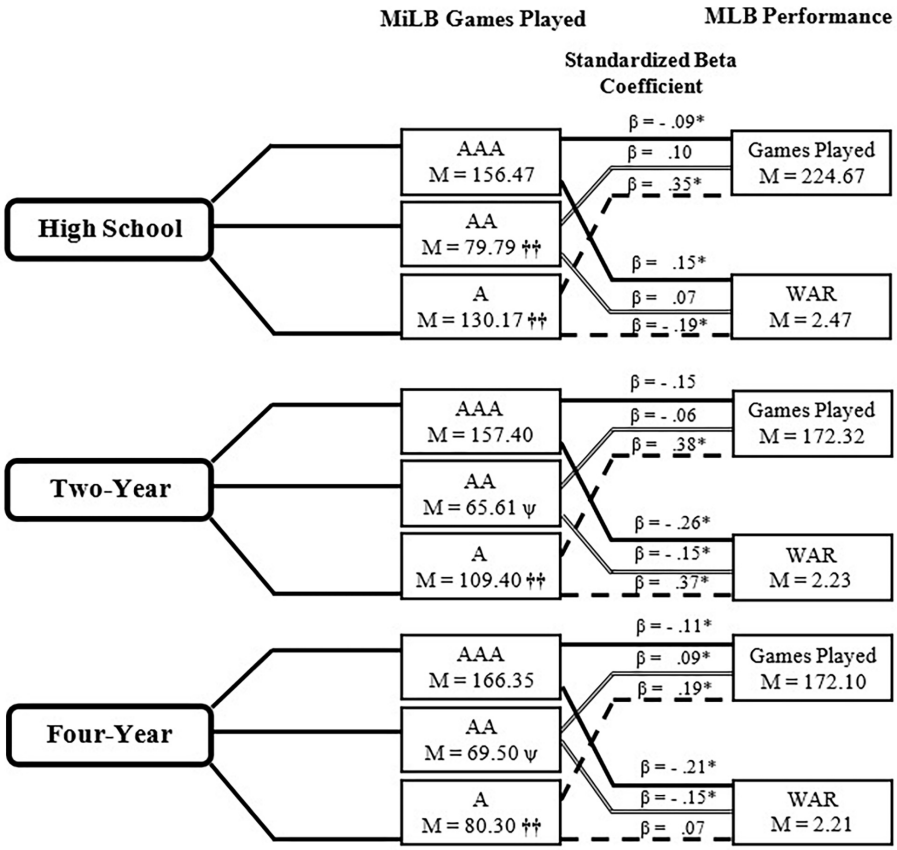

FIGURE 3 | Relationship between Minor League career and MLB performance- Pitchers. WAR, Wins Above Replacement, ††Significant difference ($p < 0.05$) from two other institutions at that level. ΨSignificant difference ($p < 0.05$) from High School institution at that level. β Signifies standardized beta coefficient from regression model with A, AA, AAA Games Played used as predictors of Major League Baseball Games Played and Wins Above Replacement; *$p < 0.05$.

as precocious, or having exceptional potential (accurately or inaccurately), resulting in their promotion through MiLB at a faster rate than typically seen through the college/university pathway. Athletes who choose to develop in the college/university pathways (particularly the 4 year route) may simply be inclined to finish their degrees and/or may have greater commitment to their teams (e.g., greater group and task cohesion; see Eys et al., 2015). It is also possible that high-school-drafted athletes start their minor league careers younger (typically 18 years old), allowing them to accrue the necessary A and AA games needed to assess their ability at a younger age than college/university players.

While the MLB debut ages were different amongst the three pathways, this did not appear to influence overall career success. Although the high-school-pathway pitchers, with younger debut ages, had a greater number of total MLB GP, there were no significant differences between the pathways with respect to WAR. The lack of a relationship between GP and WAR for the high-school-pathway pitchers could support the existence of a sunk cost effect (see Koz et al., 2012; Keefer, 2018). Perhaps their identification as precocious, and worthy of being drafted out of high-school, predisposes coaches and administrators to invest time and opportunities for these athletes to play despite evidence to the contrary. Future research should address this by exploring age of debut as a verifiable performance indicator, particularly for pathways that may be subject to the sunk cost effect. The fact that the three main developmental pathways are not directly related to career success is also supported by their equal representation in the top 20% of GP at MLB. Although these pathways may contain ostensible differences, it is possible that the developmental experiences accumulated within each pathway mediate and/or moderate later career success. Further inquiries into this concept may have fruitful implications for pathway and talent identification research.

While there was no direct relationship between the three primary developmental pathways and career success, results did suggest there are indicators at the MiLB level of future MLB career success, and that these indicators differ according to playing position. The negative relationships between AAA and AA GP and MLB GP *and* WAR in position players suggest more GP at these levels is associated with decreased MLB career success. This finding appears to indicate that less-skilled players are spending more time at MiLB levels and are unable to successfully transition to the MLB. The 4 year cohort also displayed a significant, negative relationship between "A" GP and MLB GP/WAR, likely because they are not expected to spend as much time at this level (because of their college experience). As

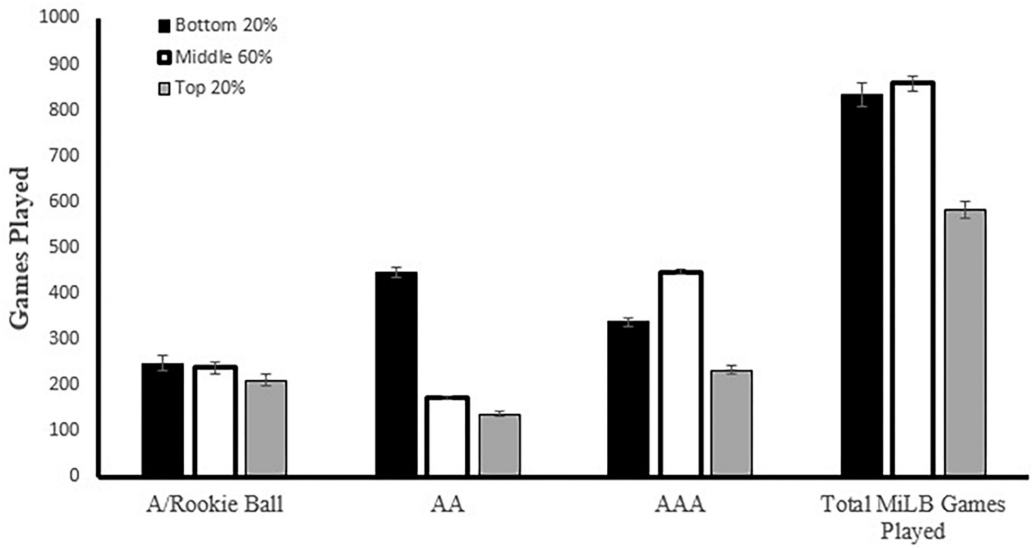

FIGURE 4 | Position Players' relationship between Minor League Baseball Games Played (MiLBGP) and Major League Baseball Games Played (MLBGP) performance. MLB GP sorted into percentiles: **Top** 20%, **Middle** 60%, **Bottom** 20%.

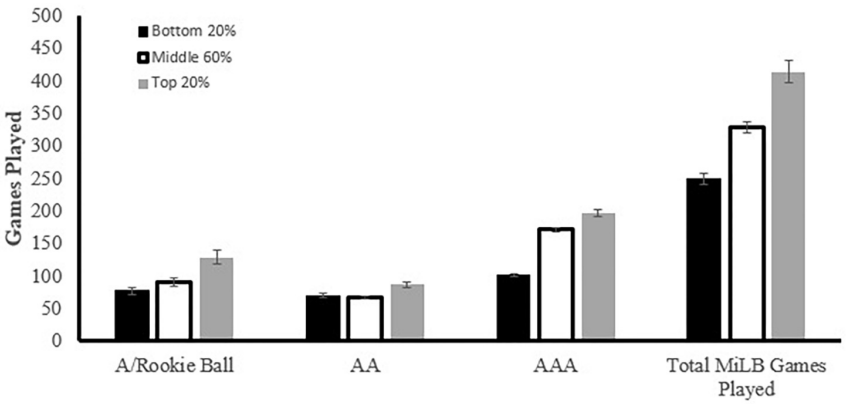

FIGURE 5 | Pitchers' relationship between Minor League Baseball Games Played (MiLBGP) and Major League Baseball Games Played (MLBGP) performance. MLBGP sorted into percentiles: **Top** 20%, **Middle** 60%, **Bottom** 20%.

such, players who play more games at the A level are presumably not as talented as those that quickly progress past this level.

Similar trends were observed for *pitchers*, with a negative relationship between AAA GP and MLB GP and WAR. However, a significant positive correlation was observed between A GP and MLB GP, along with finding that pitchers in the top 20% of MLB GP played more total MiLB games than pitchers in the bottom 80% of GP. These results are opposite to what was found for position players, and this discrepancy is difficult to account for. Perhaps young talented pitchers must flourish at A with more GP before progressing to higher levels. Spurr and Barber (1994) explored the relationship between total time spent at A and the outcome for a pitcher (promotion or demotion). Results suggested the amount of time spent at this level was related to performance metrics (i.e., Earned Run Average and strikeouts), and the more a pitcher diverged from the league mean in either direction, the quicker a decision was made about their outcome. These results, in accordance with the positive correlation observed between A GP and MLB GP, suggests that pitchers who demonstrate consistent performance (close to or above league average) may be afforded more opportunities in the MLB. There may also be unique task constraints to pitching that

require additional developmental time (i.e., MiLB GP) to acquire strength and refine skill acquisition and consistency. Indeed, an abundance of research has outlined the biomechanical intricacies involved in elite pitching (Stodden et al., 2001, 2005) and possible mechanisms that facilitate acquisition of skilled throwing (Fleisig et al., 1999; Stodden et al., 2006). It is also possible that the more games you appear in as a pitcher, the better you are/more chances you will get at the MLB level. Future research would benefit from exploring the potential mechanisms that contribute to the different developmental patterns of pitchers and position players. For example, it may be useful to include performance metrics at MiLB (e.g., earned run average for pitchers and batting average for position players) in future studies on MLB athlete development.

Regarding stage based development models (i.e., DMSP, FTEM, and LTAD), the present study illuminates the notable variation that may be present within different stages, particularly past adolescents. Although these models attempt to maximize generalizability, it is important that nuances in athlete development are not overlooked. Future research and models should strive to address diverse pathways and to understand what qualities make a specific pathway optimal for certain athletes. These findings may also be of interest to young players and their families when they are deciding which pathway to embark on (i.e., when balancing the pros and cons). However, additional research is needed to understand why athletes choose certain pathways. Factors such as their personal characteristics, socioeconomic status, aptitude for higher education, and geographic location of development likely influence this decision in variable ways. As such, it is important to note that this study was exploratory in nature and serves as a starting point for understanding non-linear development. Indeed, more comprehensive work in this area could lead to better identification of desirable developmental experiences, particularly within the developmental trajectories to MLB.

While this study provided some novel information about athlete development, it was not without limitations. We did not include athletes who were drafted but did not play a game at the MLB level. Not including this information may skew our understanding of the effectiveness of each pathway in terms of athlete development. It may be interesting to explore if one of the pathways, or MiLB indicators, is disproportionately related to the likelihood of never reaching MLB. Furthermore, while we were interested in exploring the variations in athlete development associated with different pathways, we collapsed the 17 independent pathways down to three for the purposes of analyses. While this decision was based on sample size and commonalities between similar pathways, there may have been interesting variations in athlete development *within* the three pathway groups. When interpreting our results, it is also necessary to acknowledge the debate between statistics, such as WAR. We chose to use bWAR as an indicator of MLB career success for its ease of accessibility and comprehension. However, others advocate the use of alternative WAR metrics (see Baumer et al., 2015, for a review of WAR statistics and the advocacy for openWAR). While we do not believe that a different WAR metric would dramatically alter our conclusion, it is possible that it could alter some of our results.

In summary, the heterogeneity of athlete development pathways in this and other sports is becoming increasingly relevant for practitioners working in sport. The findings in this study are indicative of non-linear development, and demonstrate that the pathways to success are diverse. Furthermore, operationalization of the term success in athlete development and talent identification literature appears to be subjective. As such, identification of desirable developmental pathways and optimal characteristics within each pathway may be contingent on how success is contextualized. Specific to MLB, while career success can be defined from several different vantage points, acknowledging the developmental variance leading to elite-performance involvement is important for a more complete understanding of the challenges faced by talent identification and development systems.

DATA AVAILABILITY STATEMENT

All datasets collated for this study were generated from publicly available information. The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

This study was exempt from ethical approval procedures as all data is publicly available and retrospective.

AUTHOR CONTRIBUTIONS

MM and NW contributed to the conception and design of the study, and performed the statistical analysis. MM organized the database and wrote the first draft of the manuscript. All authors wrote sections of the manuscript, contributed to manuscript revision, and read and approved the submitted version.

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A Conceptual Model of Engagement Profiles Throughout the Decades of Older Adulthood

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Engagement with life is essential to successful aging. This study explored 'how' and 'why' engagement profiles change throughout older adulthood using a mixed methods design. Fifty-four participants (mean age = 79.17 years, age range = 65–97 years; 21 males, 33 females) completed questionnaires to quantify 'past' and 'present' engagement. Focus groups and semi-structured interviews were completed with a subsample of participants (n = 42). Results highlight participation in a variety of activities across the decades of older adulthood, and identify that engagement in productive and active leisure pursuits decreased in frequency with increasing age, while the frequency of social and passive leisure activities remained stable. Changes in engagement were a function of five themes derived from the fundamental qualitative description: (a) health and physical limitations, (b) death, (c) freedom, (d) desire, and (e) external influential factors. Patterns of engagement frequency are interpreted in consideration of qualitative findings, creating an integrated discussion of 'how' and 'why' activity profiles emerge during older adulthood. This study highlights the value of a mixed methods approach when examining engagement in older adulthood, and provides practical implications for practitioners who seek to support a successful aging process.

Keywords: aging, active, positive, multidimensional, activity

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INTRODUCTION

Over the last 50 years there has been a significant investment in research on successful aging (SA), where it has been defined as both an outcome and a process (Baltes and Carstensen, 1996; Fisher and Specht, 1999). While there has been no shortage of research effort devoted to defining the term SA, literature has failed to identify a single, universal definition (Rowe and Kahn, 1987, 1997; Peel et al., 2004; Phelan et al., 2004; Bowling and Dieppe, 2005; Depp and Jeste, 2006, 2009; Cosco et al., 2014; Martin et al., 2015). However, regardless of how SA has been defined, it has benefited the aging process by consistently providing a positive overtone.

Several conceptualizations of SA have been presented in the research literature. As an example of an outcome-oriented approach, Rowe and Kahn's model defines SA as the intersection of three components: low probability of disease and disease-related disability; high cognitive and physical functioning; and engagement with life. This model stimulated debate regarding the existence of individual control over the ability to age successfully. To illustrate, factors such as diet, exercise, and smoking contribute significantly to disease-related processes. Therefore, by managing a healthier lifestyle, it may improve the odds of SA. Despite its theoretical nature, this model is testable as it is

possible to determine whether "success" is present in any, or all three components, thereby defining that individual as successful. Early criticisms of this model commented that its dichotomous approach to defining SA failed to address the heterogeneity of aging individuals, and that it did not account for psychosocial influences on aging. While many studies attempted to identify predictors of successful aging (e.g., life satisfaction, involvement in games and physical activity, income), the establishment of a single comprehensive model, or testable definition of SA has been elusive.

In addition to objective efforts to measure SA, subjective accounts of the aging process have posited that many older adults believe that they are aging successfully despite the presence of medical issues. Strawbridge et al. (2002) reported that 18.8% of older adults were aging successfully when objectively assessed against measures aligned with Rowe and Kahn's model, while 50.3% subjectively believed they were aging successfully. Similarly, Montross et al. (2006) reported that 92% of respondents rated themselves as aging successfully. These subjective ratings were positively correlated with resilience, activity level, and number of close friends, which suggests a relationship between perceptions of successful aging and engagement with life, and supports the importance of examining both process and outcome as they relate to SA. Evidently, when provided with the opportunity to assess one's personal level of success, many older adults believe they are successful, imparting a positive overtone on the aging process.

Mathematical modeling of SA has been limited, with the existing studies employing confirmatory factor analysis and structural equation modeling to identify a multidimensional perspective of SA. In their models, Lee et al. (2011) and Geard et al. (2018) included a social factor (i.e., engagement with friends/family) which promoted SA. Similarly, SA was also promoted by a leisure factor (i.e., exercise and vacation time) included within the model proposed by Lee et al. (2011). These studies are the first to mathematically model engagement, as defined by social and leisure factors.

Historically, engagement with life has been the most understudied component of Rowe and Kahn's original theoretical model, which is evidenced by only 13–26% of definitions of SA including a social and/or engagement measure (Bowling and Dieppe, 2005; Depp and Jeste, 2006). Engagement has been conceptualized in narrow and broad terms, and has been described as an outcome measure, and an antecedent of SA (Menec, 2003; Pruchno et al., 2010). While a host of variables related to engagement have been used as predictors of successful aging (games/sports – Menec, 2003; visiting friends/reading/watching television – Montross et al., 2006), very little is known about the changing nature of engagement, with most studies employing a cross-sectional research design. In addition, it is a unique component of SA, compared to health and functioning, as it is modifiable (Everard et al., 2000) and exists in a variety of forms (i.e., passive leisure, productive activities).

Early definitions of engagement focused on interpersonal relationships and continued participation in productive activities (Rowe and Kahn, 1997). However, definitions have recently been expanded to include regenerative (e.g., eating), passive leisure (e.g., reading), active leisure (e.g., walking), social (e.g., visiting, travel), and instrumental activities (e.g., shopping, cleaning) (Bath and Deeg, 2005; Maier and Klumb, 2005; Mendes de Leon, 2005; Liffiton et al., 2012). In a recent qualitative study, Carr and Weir (2017) identified that three primary themes consistently defined successful aging across three decades of older adulthood (65 to 74, 75 to 84, 85+ year olds): staying healthy, active engagement in life, and keeping a positive outlook on life; again, highlighting the importance of engagement to ongoing success. Despite a broadening of activities that represent engagement, and the recognition by older adults that engagement is an important component of successful aging, previous work has not identified whether the types of activities older adults participate in change across stages of older adulthood. For a comprehensive examination, the present study uses the term 'engagement' as an all-encompassing concept for the various elements of active engagement in life (i.e., interactions with others and participation in activities), as it is not limited by terms such as 'social' and 'productive' (Mendes de Leon, 2005).

Regardless of the nomenclature subscribed to, literature suggests that engagement provides a unique and essential component to various models of successful aging. Thus, from both a research and a practical standpoint, it may be advantageous to understand the demographics of older adults who tend to maintain an active engagement in later life despite age-related changes. Baltes and Carstensen (1996), who provide a process-oriented approach to SA, suggest that relying solely on normative outcomes (e.g., how quickly you can rise from a seated position) limits an understanding of the heterogeneity among and within older adults. Like Salthouse (1991), who referenced accommodation, remediation, and compensation as strategies for dealing with cognitive decline, Baltes and Carstensen (1996) defined successful in relative terms as "the attainment of goals which can differ widely among people and can be measured against diverse standards and norms" (p. 399). They were interested in the processes by which older adults achieved success in a time where there were increasing limitations in psychological, biological, and social resources. They introduced a metamodel of SA incorporating a lifespan view that focuses on the processes of selection, compensation, and optimization to conceptualize the strategies older adults use to age well in the face of increasing losses and limitations (Baltes and Baltes, 1990).

By adopting a lifespan view it is possible to rely on both outcome- and process-oriented views of SA to understand changes in engagement over the decades of older adulthood. The benefits of ongoing engagement include reduced mortality risk (Bassuk et al., 1999; Mendes de Leon et al., 2003; Menec, 2003; Glass et al., 2006), improved physical and cognitive function (Bassuk et al., 1999; Everard et al., 2000; Seeman et al., 2001; Bath and Gardiner, 2005; Bennett, 2005), and psychological health benefits (Seeman et al., 2001; Menec, 2003; Glass et al., 2006). In the present study, employing a mixed methods approach allowed engagement to be examined as both an outcome and process, with the integration of results creating a fuller understanding of the changing nature of engagement across a variety of productive, social, active leisure, and passive leisure activities. The overarching goal was not only to identify activity profiles and changes

in frequency of participation, but the underlying reasons why those changes might occur.

MATERIALS AND METHODS

Participants

A cross-sectional sample of 54 community-dwelling older adults (67–95 years; $\underline{M}$ age = 79.17 years), divided across three decades of older adulthood (n = 21, 65–74 years; n = 21, 75–84 years; n = 12, 85 + years – 21 males, 33 females) were recruited from local organizations, including a senior's activity center, walking group, exercise class, and church, and ultimately by 'word of mouth' in which information regarding the study was provided informally (e.g., by a friend). Given that the participants were community-dwelling older adults, the study sample reflects an aging population that had maintained some level of engagement in a variety of activity types. To further broaden recruitment, snowball sampling was employed allowing participants outside the specific recruitment locations to participate. Additional demographic information about the study sample can be found in **Table 1** (see also Carr and Weir, 2017). All participants completed Part 1 assessing 'how' engagement had changed. A subsample of participants (n = 42; mean age = 79.6 years; n = 17, 65–74 years; n = 17, 75–84 years; n = 8, 85 + years; 19 males, 23 females) from Part 1 were recruited to participate in Part 2 assessing 'why' engagement had changed. Interest to complete Part 2 of the research study was indicated by participants on their participant profile, each of whom were then contacted by the primary investigator. Recruitment for Part 2 of the study (qualitative analysis) was stopped once data saturation was met.

Procedure

'How'

This component was evaluated quantitatively by having participants complete two questionnaires aimed at assessing their current and past (5-years ago) engagement in productive (volunteer work, light housework, care for others, employment, etc.), social (family/friends, visiting others, church related activities, etc.), passive leisure (reading, bingo/games, musical instrument, etc.), and active leisure (walking, moderate sports, strenuous sports, exercise, etc.) activities. The questionnaires consisted of 30 identical items and differed by instructions. The "present engagement" questionnaire asked participants to

TABLE 1 | Participant demographics included in 'Part 1: Quantitative Analysis' and 'Part 2: Qualitative Analysis.'

Variable	65–74 year olds		75–84 year olds		85 + year olds		Total sample	
Study	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Mean Age (sample size) Range (years)	70.3 (n = 21) (65–74 years)	70.1 (n = 17) (65–74 years)	78.4 (n = 21) (75–84 years)	78.4 (n = 17) (75–84 years)	89.2 (n = 12) (85–97 years)	90.6 (n = 8) (87–97 years)	79.2 (N = 54)	79.6 (N = 42)
Sex								
Male	7 (33.3%)	7 (41.2%)	9 (42.9%)	8 (47.1%)	5 (41.7%)	4 (50.0%)	21 (38.9%)	19 (45.2%)
Female	14 (66.7%)	10 (58.8%)	12 (57.1%)	9 (52.9%)	7 (58.3%)	4 (50.0%)	33 (61.1%)	23 (54.8%)
Highest level of education								
Elementary school	1 (4.8%)	0 (0%)	1 (4.8%)	1 (12.5%)	2 (16.7%)	1 (12.5%)	4 (7.4%)	2 (4.8%)
High school	8 (38.1%)	8 (47.1%)	11 (52.4%)	4 (50%)	5 (41.7%)	4 (50%)	24 (44.4%)	21 (50.0%)
College	4 (19.0%)	3 (17.6%)	5 (23.8%)	2 (25.0%)	4 (33.3%)	1 (25.0%)	13 (24.1%)	9 (21.4%)
University	4 (19.0%)	2 (11.8%)	4 (19.0%)	1 (12.5%)	1 (8.3%)	1 (12.5%)	9 (16.7%)	6 (14.3%)
Post-graduate	4 (19.0%)	4 (23.5%)	0 (0.0%)	0 (0%)	0 (0.0%)	0 (0%)	4 (7.4%)	4 (9.55)
Household Income								
≤$20,000	0 (0.0%)	0 (0%)	3 (14.3%)	2 (11.8%)	2 (16.7%)	2 (25.0%)	5 (9.3%)	4 (9.5%)
≤$40,000	7 (33.3%)	5 (29.4%)	1 (4.8%)	1 (5.9%)	4 (33.3%)	2 (25.0%)	12 (22.2%)	8 (19.0%)
≤$60,000	3 (14.3%)	3 (17.6%)	3 (14.3%)	1 (5.9%)	1 (8.3%)	1 (12.5%)	7 (13.0%)	5 (11.9%)
≤$80,000	1 (4.8%)	1 (5.9%)	4 (19.0%)	4 (23.5%)	1 (8.3%)	1 (12.5%)	6 (11.1%)	6 (14.3%)
>$80,000	2 (9.5%)	2 (11.8%)	1 (4.8%)	1 (5.9%)	0 (0.0%)	0 (0%)	3 (5.6%)	3 (7.1%)
Prefer not to answer	8 (38.1%)	6 (35.3%)	9 (42.9%)	8 (47.1%)	4 (33.3%)	2 (25.0%)	21 (38.9%)	16 (38.1%)
Living environment								
House	15 (71.4%)	14 (82.4%)	15 (71.4%)	17 (100%)	9 (75.0%)	7 (87.5%)	39 (72.2%)	38 (90.5%)
Apartment/condominium	6 (28.6%)	3 (17.6%)	6 (28.6%)	0 (0%)	2 (16.7%)	1 (12.5%)	14 (25.9%)	4 (9.5%)
Retirement residence	0 (0.0%)	0 (0%)	0 (0.0%)	0 (0%)	1 (8.3%)	0 (0%)	1 (1.9%)	0 (0.0%)
Living arrangement								
With spouse/partner	10 (47.6%)	7 (41.2%)	14 (66.7%)	13 (76.5%)	2 (16.7%)	2 (25.0%)	26 (48.1%)	22 (52.4%)
With family	2 (9.5%)	2 (11.8%)	2 (9.5%)	1 (5.9%)	2 (16.7%)	0 (0%)	6 (11.1%)	3 (7.1%)
Alone	9 (42.9%)	8 (47.1%)	5 (23.8%)	3 (17.6%)	8 (66.7%)	6 (75.0%)	22 (40.7%)	17 (40.5%)

Percent values represent percentage of the sample within separate decades of life.

report current levels of engagement, while the "past engagement" questionnaire asked participants to report levels of engagement 5 years ago. It is important to note that retrospective methods of data collection in older adults are evidenced to be an accurate source of information (Blair et al., 1991; Falkner et al., 1999; Klumb and Baltes, 1999; Young et al., 2008; MacDonald et al., 2009). Both questionnaires utilized a four-point Likert scale to determine weekly participation: 0 times per week, 1–2 times per week, 3–4 times per week, and 5–7 times per week. The 'Present Engagement Questionnaire' also required participants to categorize each of the 30 activities as either productive, social, active leisure, or passive leisure. To ensure consistent conceptualization of each term, theoretically-based definitions of each activity type were provided to participants.[1] Binomial probability analysis was used to determine the activity categorization. Where the analysis was not significant, categorization was achieved through consensus in the focus groups.

'Why'

Participants aged 65–84 years participated in one of six structured focus groups segregated by decade of older adulthood to allow for homogeneity within a focus group relating to life experiences to date. Three focus groups were conducted with 65 to 74 year olds (n = 17) and three focus groups were conducted with 75 to 84 year olds (n = 17; detailed demographic information separated by decade of life is provided in **Table 1**). Five to six participants were included in each focus group, which were audio recorded and approximately 75 to 120 min in duration (Kitzinger, 1995). To meet the needs and/or preferences of the participants, focus groups were conducted in convenient locations (e.g., senior center, church, etc.). Each focus group progressed through an ice breaker question where participants identified a favorite activity, followed by a 'discussion-starter' which required participants to record and discuss five reasons they valued engaging in activity (Morgan, 1997). Next, participants completed a group activity. Cards identifying the 30 activities included on the 'past' and 'present' engagement questionnaires were provided. Within each focus group, participants were required to come to a consensus regarding the categorization of each activity as productive, social, active leisure, or passive leisure. This activity led into the main discussion regarding 'why' engagement profiles changed throughout older adulthood. After all the questions in the structured focus group guide had been discussed, the final question addressed any remaining thoughts, concerns, or viewpoints. To increase interviewer reliability and richness of data collected, one pilot focus group was conducted (Appleton, 1995).

In addition to focus groups, semi-structured interviews were completed with a random sample of four participants from each of the two age groups (65 to 74, 75 to 84 year olds), as such a data collection method can provide in-depth insight on themes derived from focus group research (Morgan, 1997). Interviews facilitated participation for individuals 85 years of age and older who were dependent on others for direct care and transportation. Therefore, one-on-one interviews were used as a substitute for focus groups among individuals in the oldest decade of adulthood (n = 8). The semi-structured interviews were conducted at a location selected by the participant, were audio recorded, and lasted approximately 15 to 30 min. Semi-structured interviews for the participants 85 years of age and older followed the standardized interview guide developed for the focus groups, except for the group activity. Semi-structured interviews conducted as a follow-up to focus groups used individualized interview guides based on participants' responses to the 'past' and 'present' engagement questionnaires. Flexibility within the semi-structured interviews was permitted using appropriate probes to extract the greatest amount of data from each participant (Fossey et al., 2002).

Data Analysis

'How'

To determine differences in participation between activity types, the 30 activities identified on the 'past' and 'present' engagement questionnaires were grouped according to the activity categorization determined by the participants (**Table 2**). Participant responses on the 'past' and 'present' engagement questionnaires were coded so that higher numbers represented a greater frequency of weekly participation (1 = 0 times per week, 2 = 1–2 times per week, 3 = 3–4 times per week, 4 = 5–7 times per week); therefore, if frequency of participation was 2.5 this would correspond to 1–4 times per week. Differences were examined through a mixed design 3 (Age) × 2 (Time) × 4 (Activity Type) ANOVA with repeated measures on 'time' and 'activity type.' To examine differences in participation within each activity type four separate mixed design ANOVAs were conducted to include one analysis for each activity type. These varied based on the number of activities per category: productive (n = 9); social (n = 8); active leisure (n = 7); passive leisure (n = 6). Significant F-values were determined at a p-value of 0.05. Greenhouse–Geisser correction was employed for all analyses as sphericity was violated. Only F-values having at least a small effect size ($\eta_p^2 \geq 0.01$) were analyzed to ensure the presence of practical significance within the associated effect (Cohen, 1988). Significant interactions were examined using analysis of simple effects. Where applicable, significant F-values were *post hoc* tested through pairwise comparisons and evaluated based on Bonferroni's adjustment for multiple comparisons.

'Why'

Data from both the focus groups and semi-structured interviews were transcribed verbatim and corrected against audiotapes. Focus group and interview transcripts remained separate during the analysis to allow unique themes to emerge due to the different social contexts under which data were collected (i.e., group setting versus individual setting). This was an important consideration as the differing data collection methods had the potential to influence participants' responses, such as through the promotion of socially acceptable answers during focus groups or

[1] Productive = Create societal value and are carried out for the purpose of their outcome; **Social** = Provide interactions among others; **Passive Leisure** = Tend not to include a social component and are commonly carried out by a single person without any necessary company; **Active Leisure** = Help with the maintenance of physical functioning and tend to require a larger expenditure of metabolic energy.

TABLE 2 | Categorization of specific activities into four activity types.

Activity	Binomial probability	Focus group	*N*
Productive activities			
Volunteer work		X	52
Light housework	X		53
Care for others		X	52
Educational activities	X		53
Playing a musical instrument		X	48
Full- or part-time paid employment	X		49
Home repairs	X		51
Heavy housework		X	51
Service, club, or fraternal organization activities		X	51
Social activities			
Family/friendship activities	X		53
Visiting others	X		53
Cultural activities		X	52
Church-related activities		X	50
Bingo, cards, or other games	X		51
Attending theater events		X	52
Neighborhood or community activities		X	52
Phone conversations	X		53
Active leisure activities			
Moderate sports or recreational activities		X	52
Outdoor gardening, sweeping the balcony or stairs		X	53
Strenuous sports or recreational activities	X		52
Exercise to increase muscle strength and endurance		X	52
Taking a walk outside your home or yard		X	53
Light sports or recreational activities		X	52
Lawn work or yard care		X	51
Passive leisure activities			
Watching television	X		53
Handicrafts		X	52
Reading	X		53
Listening to the radio or music	X		53
Computer activities		X	50
Crosswords, puzzles, etc.	X		51

N = total sample size of participants that categorized each specific activity.

sharing of intimate details during one-on-one interviews. Thus, group influences were considered when analyzing focus group responses and therefore, maintaining separation between data collection approaches allowed comparisons of themes that did, or did not emerge, due to contextual factors (Smithson, 2000).

Data analysis included qualitative content analysis (Sandelowski, 2000) to provide a coherent organization of consistencies within qualitative data (Patton, 2002). Based on the transcribed data, relevant information was highlighted to create broad themes among responses. Using an inductive approach, *meaning units* were developed from the specific responses within these broad themes (Tesch, 1990; Côté et al., 1993). This process occurred within and between focus groups and semi-structured interviews (Maykut and Morehouse, 1994). Subsequently, through continuous comparisons and organizations, distinct themes based on commonalities of *meaning units* were created (Tesch, 1990; Côté et al., 1993). This constant comparative method continued until no new themes were identified and data saturation was achieved (Taylor and Bogdan, 1984; Ryan and Bernard, 2003). Successful attainment of data saturation and replication, along with concurrently engaging in data collection and analysis, supported the rigor of the qualitative data analysis (Morse et al., 2002). This analytical approach also ensured that the themes that emerged remained 'close' to the data (Taylor and Bogdan, 1984; Sandelowski, 2000). Comparisons of the themes across qualitative methods (i.e., focus groups versus interviews) resulted in collapsing all data together, as no new themes emerged from semi-structured interviews. Similarities and differences between decades of life (i.e., 65–74, 75–84, 85 + years of age) were also examined and identified where applicable. In total, 13.5 h of audio recording produced 278 pages of transcripts to be analyzed. From these transcripts, 240 meaning units were identified, which yielded 5 themes and 17 subthemes. Methodological rigor was further established through the review of the data analysis by the senior author, who independently categorized meaning units into higher order themes. This led to a slight reorganization of meaning units and themes to achieve agreement between the two investigators. Where agreement could not be attained, the meaning unit was removed as it did not provide reliable data (Morse et al., 2002; Patton, 2002). Additionally, researcher biases were systematically documented through note-taking during data analysis, as such explicit awareness may reduce biases from influencing results (Morse and Richards, 2002).

RESULTS

'How'

Part 1: Quantitative Analysis

The examination of frequency of weekly participation across the four activity types revealed a significant interaction between time and activity type [$F(2.63,134.19) = 4.48$, $p = 0.007$, $\eta_p^2 = 0.081$]. In order to determine whether the pattern of participation across activity types was consistent, separate one-way ANOVAs were conducted comparing activity type in the past, [$F(3,215) = 25.87$, $p = 0.000$, $\eta_p^2 = 0.268$], and in the present, [$F(3,215) = 42.90$, $p = 0.000$, $\eta_p^2 = 0.378$]. In the past (i.e., 5 years ago) weekly participation in passive leisure activities ($M = 2.81$, $SD = 0.45$) was significantly greater than the frequency of participation in any other activity type (productive: $M = 1.99$, $SD = 0.44$; social: $M = 2.27$, $SD = 0.39$; active leisure: $M = 2.30$, $SD = 0.65$); and, the frequency of weekly participation in active leisure activities was greater than that of productive activities. Similarly, in the present, passive leisure activities ($M = 2.78$, $SD = 0.47$) were participated in more often than all other activity types

(productive: M = 1.83, SD = 0.39; social: M = 2.28, SD = 0.33; active leisure: M = 2.11, SD = 0.56), while participation in social activities was greater than participation in productive activities. **Figure 1** illustrates the frequency of past and present weekly participation for each activity type.

This analysis also revealed a main effect of age, [$F(2,51) = 4.86$, $p = 0.012$, $\eta_p^2 = 0.160$], where 65–74 year olds (M = 2.42, SD = 0.45) reported higher weekly participation when compared to participants who were 85 years of age and older (M = 2.09, SD = 0.45). However, on average, both age cohorts participated in activity between one and four times a week. In addition, there was a main effect of time [$F(1,51) = 7.31$, $p = 0.009$, $\eta_p^2 = 0.125$], which identified more frequent weekly participation in the past (M = 2.31, SD = 0.34) compared to the present (M = 2.22, SD = 0.30). While a main effect of activity type was also evidenced [$F(2.48,126.62) = 60.13$, $p = 0.000$, $\eta_p^2 = 0.541$], this factor was included in the interpretation of the significant interaction and was not further analyzed.

Productive activities

Weekly participation in productive activities revealed a significant interaction between time and activity [$F(6.12,312.00) = 3.78$, $p = 0.001$, $\eta_p^2 = 0.069$]. Results from a series of repeated measures ANOVAs examining the difference between past and present weekly participation for each productive activity are reported in **Table 3**. Specifically, the frequency of weekly participation for five productive activities (volunteer work, care for others, employment, home repairs, heavy housework) was significantly lower in the present compared to the past, while the remaining four productive activities experienced no change in the frequency of weekly participation over time. This analysis also revealed a significant main effect of age [$F(2,51) = 6.54$, $p = 0.003$, $\eta_p^2 = 0.204$]. It was determined that 65–74 year olds (M = 2.10, SD = 0.96) reported a significantly higher frequency of weekly participation in productive activities when compared to participants 85 years of age and older (M = 1.55, SD = 0.75). Additionally, there was a main effect of time, [$F(1,51) = 10.00$, $p = 0.003$, $\eta_p^2 = 0.164$], which identified a decrease in the frequency of weekly participation in productive activities from the past (M = 1.94, SD = 0.41) to the present (M = 1.80, SD = 0.38). There was also a main effect of activity [$F(6.70,341.54) = 28.85$, $p = 0.000$, $\eta_p^2 = 0.361$], however, this factor was included in the interpretation of the significant two-way interaction, and therefore was not considered for further analysis.

Social activities

Participation in social activities indicated a significant main effect of activity [$F(5.55,282.84) = 54.17$, $p = 0.000$, $\eta_p^2 = 0.515$]. Family and friendship activities (M = 3.30, SD = 0.78) and phone conversations (M = 3.24, SD = 0.78) were participated in significantly more often on a weekly basis than all other social activities (visiting others, cultural activities, church related activities, bingo/games, attending theater, neighborhood activities). Additionally, participants reported visiting others (M = 2.55, SD = 0.73) significantly more often than participating in cultural activities, bingo, cards, or other games, theater events, and neighborhood or community activities. No other significant differences were identified between social activities with respect to participants' frequency of weekly participation.

Active leisure activities

Frequency of weekly participation revealed a significant main effect of time [$F(1,51) = 8.72$, $p = 0.005$, $\eta_p^2 = 0.146$]. Participants engaged significantly less often in active leisure activities in the present (M = 2.11, SD = 1.03) compared to the past (M = 2.31, SD = 1.04). However, when anchored to the Likert scale, participants engaged in active leisure activities between one and four times per week in both the past and the present. A significant main effect of activity was also identified [$F(4.52,230.56) = 12.26$, $p = 0.000$, $\eta_p^2 = 0.194$]. Taking a walk outside one's home or yard (M = 2.81, SD = 0.88) was participated in significantly more often on a weekly basis than all other active leisure activities (moderate sports, strenuous sports, exercise to increase strength, light sports, lawn work), except for outdoor gardening and sweeping the balcony or stairs (M = 2.59, SD = 1.04). Additionally, weekly engagement in outdoor gardening and sweeping the balcony or stairs was significantly greater than participation in light sports and recreational activities (M = 1.73, SD = 0.94), and lawn work or yard care (M = 1.96, SD = 1.07). Average participation in taking a walk outside one's home or yard, gardening and sweeping the balcony or stairs, and exercise to increase muscle strength and endurance were reported to occur between one and four times per week, whereas all other active leisure activities were reported to be participated in less than twice per week.

Passive leisure activities

Participation in passive leisure activities revealed a significant interaction between activity and age [$F(8.90,226.84) = 2.33$, $p = 0.016$, $\eta_p^2 = 0.084$]. Listening to music or the radio was the only passive leisure activity that differed significantly among age groups. Specifically, participants 85 years of age and older (M = 2.42, SD = 1.24) listened to music or the radio significantly less often than either the 65 to 74-year-olds (M = 3.45, SD = 0.80), or the 75 to 84-year-olds (M = 3.43, SD = 0.88). On average, 65 to 84-year-olds listened to music or the radio between 3 and 7 days per week, in contrast to the 1 to 4 days per week for participants 85 years of age and older. While listening to the music or radio decreased as a function of age, the remaining passive leisure activities experienced no change. A main effect of activity [$F(4.45,226.84) = 30.83$, $p = 0.000$, $\eta_p^2 = 0.377$] was not analyzed further as it was included in the interpretation of the two-way interaction.

'Why'

Part 2: Qualitative Analysis

A sub sample (n = 42) of the participants included in 'Part 1: Quantitative Analysis' were involved in the qualitative procedures and analysis. Analysis of focus group and semi-structured interview data yielded five themes related to 'why' engagement profiles change throughout older adulthood: (a) health and physical limitations, (b) death, (c) freedom, (d) desire, and (e) influential external factors. As displayed in **Table 4**, several subthemes existed within each theme.

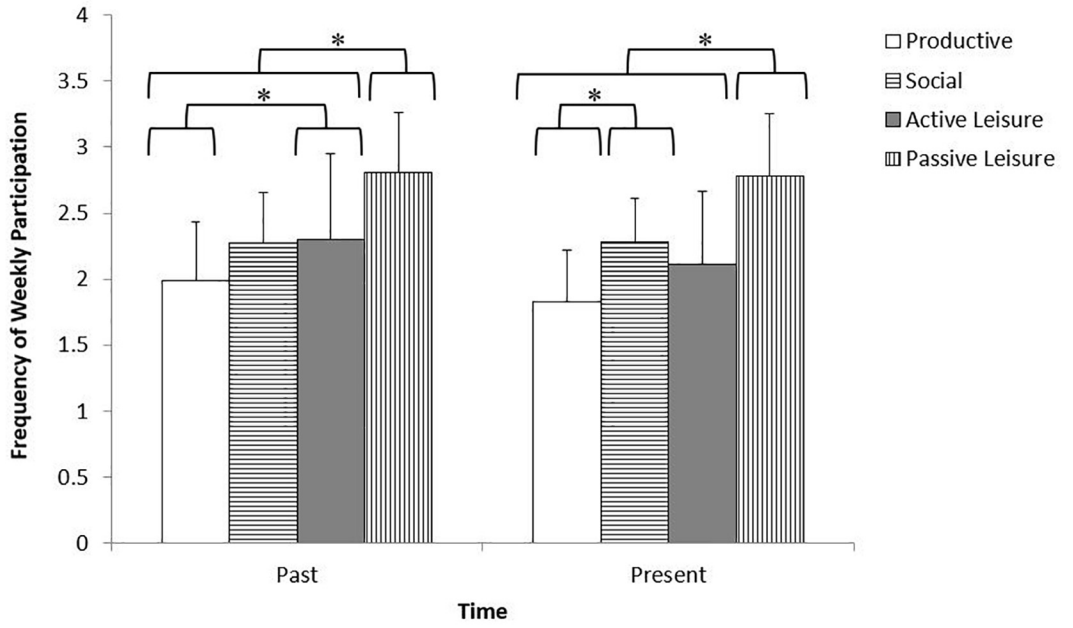

FIGURE 1 | Frequency of weekly participation in activity types separated by time. This figure illustrates the frequency of weekly participation in each activity type separated by time for adults 65 years of age and older. Scale for frequency of weekly participation corresponds to Likert scale provided on questionnaires (1 = never; 2 = seldom; 3 = sometimes; 4 = often); error bars represent standard deviation. *$p \leq 0.05$.

TABLE 3 | Past vs. present weekly participation in productive activities among adults 65 years of age and older.

Specific activity	Past Mean (SD)	Present Mean (SD)	*F*-statistic df (1, 53)	*p*-value	η_p^2
Volunteer work*	2.20 (0.96)	1.94 (0.96)	4.77	0.033	0.082
Light housework	3.24 (0.87)	3.33 (0.91)	0.38	0.540	0.007
Care for others*	2.04 (1.22)	1.72 (1.00)	4.34	0.042	0.076
Educational activities	1.65 (0.91)	1.78 (1.00)	1.60	0.212	0.029
Playing a musical instrument	1.35 (0.87)	1.39 (0.92)	0.16	0.687	0.003
Full- or part-time paid employment*	1.63 (1.14)	1.11 (0.50)	12.94	0.001	0.196
Home repairs*	1.87 (0.91)	1.63 (0.81)	10.45	0.002	0.165
Heavy housework*	2.31 (0.87)	1.89 (0.93)	11.00	0.002	0.172
Service, club, or fraternal organization activities	1.59 (0.86)	1.70 (0.92)	1.13	0.293	0.021

*Weekly participation is based on a four-point Likert scale (1 = never [0 times], 2 = seldom [1–2 times], 3 = sometimes [3–4 times], 4 = often [5–7 times]). *$p \leq 0.05$.*

Health and physical limitations

Nearly all participants discussed personal health status and limitations to physical functioning as affecting engagement in activity over the previous 5 years. Within this theme, six subthemes emerged: (a) unspecified health issues and physical limitations, (b) specified health issues and physical limitations, (c) decreased physical senses, (d) decreased energy levels, (e) progressive 'slowing,' and (f) combating health issues and physical limitations.

Unspecified health issues and physical limitations. Participants within all decades of older adulthood identified a decrease in activity because of unspecified health issues and physical limitations. Some participants, such as OU, simply blamed 'health' for a decrease in specific activities: "your health stops you from doing a lot of things, like driving, I drove and I can't anymore" (75–84 years). Other participants, such as OH, used the broad explanation of one's 'body' as the cause of a decrease in all activity: "I can't seem to do things I used to, my body won't let me" (85 + years).

Specified health issues and physical limitations. Participants discussed a general sense of limitation that resulted from a specific health issue: "I have an existing heart problem, so it doesn't allow me to do what I want to do, so there's a lot of restrictions as you age" (EG, 65–74 years). Distinct age-related differences were expressed as younger participants often spoke of specific health conditions affecting participation in sport and recreation, such as YU: "I had to get both hips replaced and that took care of the hockey and the basketball" (65–74 years). In contrast, participants within the oldest decade of adulthood focused more on fundamental activities, such as the ability to

TABLE 4 | Themes and subthemes identified as reasons for changes in engagement profiles over the previous 5 years of older adulthood.

Theme/subtheme	Meaning unit	65–74	75–84	85 +
Health And Physical Limitations				
Unspecified health issues and physical limitations	"It all boils down to health issues because we can't do as much as we used to" (FR, 75–84 years).	X	X	X
Specified health issues and physical limitations	"I have arthritis and I can't run, can't ride my bike, I can't even garden well because I can't bend over like I used to do. . . I would say arthritis has made a big difference to me as far as my active leisure" (CR, 75–84 years).	X	X	X
Decreased physical senses	"With my lack of eyesight I can't do the things that I used to do" (OL, 75–84 years).	X	X	X
Decreased energy levels	"Five years ago I could work for 2 or 3 h at a time, now I can work for 20 min to a half hour. Because I'm getting older. . . your energy seems to evaporate" (OV, 85 + years).	X	X	X
Progressive 'slowing'	"As you go along in life you just naturally slow down" (HU, 85 + years).	X	X	X
Combating health issues and physical limitations	"I'm more active now than I was 5 years ago, it's a way of combating arthritis" (IY, 75–84 years).	X	X	
Death				
Death in social circle	"My social network has shrunk considerably. . . within the last 5 years, shrunk because of death" (RR, 75–84 years).	X	X	X
Death of spouse	"I don't have a husband anymore. . . that changes your life completely. There are a lot of things that you do as a couple that you won't do by yourself" (UF, 85 + years).	X	X	X
Freedom				
Freedom of time	"You're doing things you never had time for, maybe you thought about doing but you couldn't" (FD, 65–74 years).	X	X	
Freedom of choice	"You pick and choose your activities a bit more than perhaps you did before because you're not socially obligated to do things that you may have been before" (LL, 65–74 years).	X	X	
Freedom from past priorities	"Now that the work and other things that were priorities are not, I don't have to worry about them, so I can focus more on what I need" (ED, 65–74 years).	X		
Freedom from 'sweating the small stuff'	"I think as I'm getting older, I don't 'sweat the small stuff.' You don't get upset about little things as much and you focus on what's really important. You don't care what people think as much, you're a little bit more laid back, you don't worry about things" (LL, 65–74 years).	X	X	
Desire				
Lack of desire	"You just don't have the desire. . . to participate in a physical manner. . . it's just I sit in the chair and I don't want to get up" (YO, 75–84 years).	X	X	X
Change in what is desired	"Our ideas change, what we used to like as leisure we don't care for anymore, we want to do something different" (LU, 75–84 years).		X	X
Influential External Factors				
Family role	"Changes in the family. . . I have a granddaughter and a grandson. . . that really changes your whole priority of what you do, your life is entirely different when the grandkids come along" (LL, 65–74 years).	X	X	
Finances	"Some people. . .simply can't afford on a limited income to participate like some of us do. You're going all the time and you have enough funds to enjoy that but a lot of people around, it's strictly money" (DO, 75–84 years).	X	X	
Availability of direct support	"There's a neighbor that's kind enough to cut my grass and shovel my snow, so I don't have to worry about that" (CO, 85 + years).		X	X

walk: "I don't [walk] much, I can when I have to, like we go grocery shopping and I'll trudge along the store leaning on a cart. . . I have peripheral neuropathy, nerve damage to the legs, doesn't let me walk anymore" (HU, 85 + years).

In addition to specified health issues, participants in all decades of older adulthood identified three specific physical limitations: (a) decreased strength, (b) decreased balance, and (c) pain. Decreased strength was acknowledged by participants such as GY: "we're not as strong physically. . . that's the truth of the matter, you think you're strong, but we're not as strong physically as we were" (75–84 years). Similarly, a lack of balance was recognized by participants: "our balance isn't what it was 5 years ago" (FR, 75–84 years), and was further discussed as limiting participation in activity: "they switched some of my blood pressure medication which destroyed my sense of balance. . . that means that I'm not able to do the walking I used to do" (OV, 85 + years). Finally, pain was associated with limiting participation in personally meaningful activities

by participants like EG: "My dancing has changed because it's a lot more painful than I've ever imagined" (65–74 years). This extended to participants in the oldest decade of life, such as FC, who stated "I don't go [to church] and sit on those hard chairs because it hurts my back" (85 + years). Overall, participants in all decades of older adulthood acknowledged specific health issues and physical limitations as reasons for decreasing engagement in specific activities.

Decreased physical senses. Participants in all decades of older adulthood identified decreases to one's physical senses as affecting engagement in a variety of activities over the previous 5 years. Reductions to the sense of vision was experienced by participants of all ages and created limitations for engagement in various activities. For example, EG, no longer participated in his once-enjoyed handicrafts:

> I do upholstery, which I can't do very readily anymore because my eyesight is not there, I can't thread a needle anymore, so I find that most of my activities have gone downhill. . . at one time I loved them. . . [I can't] sit at it because I can't see properly (65–74 years).

Additional passive leisure activities, such as reading, were discussed as being affected by the deterioration of one's vision: "I have problems with my eyes so reading is not high on my list" (HU, 85 + years). Eyesight was also identified as a factor in losing the ability to drive, which has the potential to broadly affect one's participation in activity as stated by CO: "I don't go out much because I can't drive anymore because of my eyes" (85 + years).

The impact of losing one's auditory ability was discussed only among participants 75 to 84 years of age. Specifically, participants identified one's ability to hear as essential to social interactions, as expressed by GR: "[my husband] can hear very little even with two hearing aids, so that has really changed our social interactions" (75–84 years). In addition, the loss of hearing was stated to affect one's enjoyment during passive leisure activities as explained by TU, "some television programs that I really enjoy and all the other shows, almost anything else on television for me anymore has become impossible, my hearing doesn't allow me to enjoy it" (75–84 years). Evidently, a decrease in one's physical senses has far reaching limitations, as participants clearly demonstrated the negative impacts of such losses.

Decreased energy levels. Participants in all decades of older adulthood identified decreased participation in active leisure activities, such as EG: "my [active leisure] has gone downhill, the energy levels are not there. . . things that I did in my past are all over" (65–74 years). This decrease in energy was also associated with a decrease in productive activities as stated by LY, who maintained full-time employment at the time of data collection:

> I'm still working full-time. . .when I come home I don't do anything, like I don't vacuum, I don't paint, I don't do any of that stuff because I don't have the energy to do all the stuff that I did 5 years ago after work (65–74 years).

As a consequence, participants indicated decreased energy levels resulting in an increase in the time spent engaging in passive leisure activities, as explained by CR: "you sit and watch TV because you're tired, you need to rest, it's not because you're dying to watch television, and you're not going to sit there and do nothing, so you turn the TV on" (75–84 years). Interpretation of the data collected alludes to a shift in time-use due to reduced energy levels, where time spent engaging in productive and active leisure activities is replaced by time spent in passive leisure pursuits.

Progressive 'slowing'. Participants often spoke of 'slowing down' in a general sense, such as DO: "I used to do things faster, now I do them much slower" (75–84 years). Similarly, DN, applied the notion of 'slowing down' to participation in social activities: "[social activities] have gone from young activities to old activities, much slower pace" (75–84 years). It is important to note that many participants, such as LU who quoted her 87-year old husband, demonstrated the maintenance of past activities despite the decrease in the pace in which the activity was completed: "I can do anything that I used to do but it takes me maybe three or four times as long to do it" (75–84 years). Overall, progressive 'slowing' with age did not necessarily affect the types of activities participated in, rather completing the activities at a slower pace allowed participants to maintain engagement in specific activities.

Combating health issues and physical limitations. This theme was dominated by participants within the youngest decade of older adulthood (i.e., 65–74 years of age). This was articulated by HD:

> I think sometimes your health dictates how you change, like I didn't particularly work out a lot but I ended up having to have heart surgery and they tell you to start working out and keep yourself in shape so suddenly things that you didn't place as high on the priority list you suddenly say, 'this is a priority, I have to do this all the time' (65–74 years).

Similarly, ED, supported this theme with a simple, all-encompassing statement: "active leisure activities do increase because you need it for fitness" (65–74 years). Evidently, individuals in the younger years of older adulthood acknowledged the importance of participating in active leisure activities to combat health issues and physical limitations and changed personal engagement patterns accordingly.

Death

All participants acknowledged that engagement over the previous 5 years had been affected by the death of individuals with whom a relationship was shared. This theme included two subthemes: (a) death in social circle, and (b) death of spouse.

Death in social circle. Deaths experienced within the participants' social circles were discussed as limiting social activities throughout all decades of older adulthood. However, this theme became more prominent among participants of older ages. Participant, OF, indicated that she had experienced the death of many friends whom she had once engaged in social activities with: "we had a group of 12 or 14 friends and we only have one couple left, and that's the thing that is limiting" (65–74 years). This experience was similar among participants in the oldest

decade of adulthood, though such participants often expressed the loss of their social circle in its entirety. For example, UF, explained that she no longer had social contacts due to the death of her friends: "I had an awful lot of lovely friends and a very good life, and they're all dead. When you get really old, everybody that you knew or you liked. . .all the couples we chummed around with are all gone" (85 + years). This view was further supported through conversation regarding social activities with CI who stated: "I've outlived all my friends," (85 + years) and FC who explained: "I haven't got any [friends], they're all dropped off. . . died" (85 + years).

The theme of 'death in social circle' also encompassed participants expressing their concern of their own impending death or the impending death of persons within their social network. However, this concern was only voiced by participants within the younger two decades of older adulthood. Impending death affected one's participation in social activities as participants often choose to engage in specific social outings to ensure visitation with friends and family prior to the death of either party. This concept was explained by HD:

> I think you become more conscientious about your family that you probably didn't see much when you were working, but now you're getting older you're thinking 'boy, they're all getting older too, I want to make contact with these people.' I wouldn't have thought about that 10 years ago, you just assume they're going to be there, too many funerals (65–74 years).

Overall, participants in the younger decades of older adulthood viewed impending death as a reason to engage in specific social activities, while participants within all decades of older adulthood (though more pronounced in the older decades) experienced a decrease in social activities following the death of individuals within their social circle.

Death of spouse. Following the death of one's spouse, participant OL expressed an overall reduction in engagement: "5 years ago we volunteered, we worked at the church, we went out every day pretty well. . . I'm no longer doing that. . . my life has changed completely" (75–84 years). Other participants spoke of a shift in time-use toward more passive leisure activities following the loss of one's spouse: "I didn't read in the day time as much when I was married, we were always on the go, there were always nice things to do" (UF, 85 + years). Participation in activity was also affected after the loss of one's spouse due to the status of being widowed, or no longer coupled. For instance, OL spoke of reductions in her social activities: "you don't get invited out as a single person as you do as a couple, I don't entertain as often because it's a big effort because you don't have any support" (75–84 years). Also creating a limitation to participating in social activities was the loss of friendships following the death of one's spouse, as explained by ET:

> "As soon as [your spouse] dies, [your friends] don't know you anymore. They don't even phone you, nothing. I couldn't believe it, and the wives don't want you to talk to their husbands. . .I was just all on my own" (75–84 years).

Consequently, the loss of one's spouse was reported to negatively impact one's participation in social activities, and resulted in a shifting of time-use toward passive leisure pursuits across all participant groups.

Freedom

A change in one's engagement profile due to a sense of freedom was unique among participants within the younger two decades of older adulthood (i.e., 65–74 and 75–84 years of age) suggesting that recognition of freedom may be a function of the length of one's time spent in one's senior years. Younger participants may feel free from the responsibilities and stresses of middle adulthood, while the participants within the oldest decade of adulthood may have become accustomed to this freedom. The theme of freedom encompassed four subthemes: (a) freedom of time, (b) freedom of choice, (c) freedom from past priorities, and (d) freedom from 'sweating the small stuff.'

Freedom of time. Participants under the age of 85 years identified an increase in participation due to an increase in free time. CR discussed an increase in participating in passive leisure activities as the increased availability of free time allowed participants to shift their time to activities they enjoyed: "I read more because I have more time and I absolutely love to read. I love to have a book. . . before you were so busy it'd take months to read a book" (75–84 years). Likewise, passive leisure activities that were previously considered a 'waste of time' had now become enjoyed during the free time of TU: "I have more time to do nothing. In my opinion, reading the newspaper was a waste of time, now I love it. It's still a waste of time, but I love it" (75–84 years). The freedom of one's time also allowed participants to increase participation in preferred productive activities in the form of volunteerism: "I started to visit people, shut-ins, so that's something I didn't do 5 years ago because I didn't have the time to do it. I've always had the interest but not the time" (IY, 75–84 years). This trend was also extended to family activities: "definitely more time with family, with my grandchild. We're able to do more because we have more time to do it" (DD, 65–74 years), as well as active leisure activities: "while you're working you're sort of mulling along, now that I'm retired I make the time to do exercises and do other things that are more enjoyable" (LL, 65–74 years), and finally, travel: "the big thing is travel. . . because you can get away. . . you have the time to travel. I couldn't take 2 months off to go away on a holiday when I was working 5 years ago" (LL, 65–74 years). Evidently, no universal pattern of time-shifting existed among the participants due to the freedom of one's time, rather participants expressed an individualized pattern of time-shifting toward personally preferred activities.

Freedom of choice. Freedom of choice was primarily discussed by participants within the youngest decade of older adulthood (i.e., 65–74 years of age) as a factor that influenced participation in activity over the previous 5 years, but was also mentioned by those between 75 and 84 years. Participants often spoke of the ability to 'pick and choose' what activities they wished to participate in, as explained by CB:

> I have choices I can make. Prior to retirement I didn't have as many choices, it was work, which was the priority.

> Coming home, I was tired at the end of the day so I didn't get out. Now I can wake up and think, 'what do I want to do today?' (65–74 years).

Participants also related the freedom of choice to their social circle; for example, GR explained a change in her social circle due to her freedom to choose her friends: "you're able to choose who you want to be friends with. When you work with people you're stuck" (75–84 years). Similar to the freedom of time associated with older adulthood, the freedom of choice was also discussed as an avenue that allowed older adults to experience greater enjoyment throughout their senior years, as explained by NR: "probably [the] quality of [your social circle] improves because you select and do what you want, you meet the people you want to, spend time with fewer people but whatever time you spend you enjoy more" (65–74 years). Therefore, the freedom of choice enabled participants to engage in activities that were personally enjoyed with social contacts they preferred, and thus no common pattern of changing engagement profiles was identified among participants based on one's freedom of choice.

Freedom from past priorities. Freedom from past priorities was frequently and extensively discussed among participants in the youngest decade of older adulthood (i.e., 65–74 years of age) and remained unique to this age group. As expected, participants, such as ED, related freedom from past priorities to retirement: "now that the work and other things that were priorities are not, I don't have to worry about them" (65–74 years). Past priorities also extended beyond formal employment to additional productive activities, such as housework, which did not hold the same importance as it did in the past as explained by FD:

> I am not as concerned with the housework as my leisure. I don't have as much emphasis on the housework, I don't really lose any sleep if something is not done, but I do care if I miss my theater or my community choir. So, there's more enjoyment now in my leisure versus the house that always needs something and at one time it was really important (65–74 years).

This shift in one's priorities to more personally enjoyed activities was also supported by NV: "now that we're in our senior years, all that stuff that was so important before like working and house cleaning. . . now I think more of maybe how much time I have left and I'm going to enjoy it" (65–74 years). Taken together, participants within the youngest decade of older adulthood identified a change in engagement patterns over the previous 5 years through the removal of past priorities which allowed participants the opportunity to prioritize activities based on the enjoyment one received from participation.

Freedom from 'sweating the small stuff'. Participants within the two youngest decades of older adulthood (i.e., 65–74 and 75–84 years of age) indicated a 'mellowing' over the past 5 years which was reported to have affected engagement in activity. This concept was articulated by DO: "as I age I find myself becoming less intense about everything. . . we let things go that we wouldn't have a few years ago" (75–84 years). This notion of 'letting things go' was applied to participation in activities by GO: "I think as you get older you get calmer, you know, 'don't sweat the small stuff.' Things don't bother you, you're not trying to cram everything into 24 h that would take 48 h" (65–74 years). This thought was supported by TF:

> At one time you were [ready] to do anything, you know 'I got to do this, let's do it and get it over with.' By the time you got that finished there was something else, but today you say, 'oh well. . . I'll wait until the next day' (65–74 years).

Freedom from 'sweating the small stuff' was also reflected in participants' carefree attitude that had emerged in the previous 5 years. For example, ED explained that she felt freer to engage in different activities:

> I'm trying different things because of where I'm at in my life. It's just like you lose the fear of what you do. . . maybe it's good that you do, and you just let go of being so serious all the time (65–74 years).

Overall, a clear change in engagement profiles due to the freedom from 'sweating the small stuff' was not revealed, however participants indicated a reduction in pressure to complete specific activities, and a greater willingness to attempt new activities.

Desire

One's desire for participation in activity was acknowledged as a factor that influenced engagement patterns over the previous 5 years for participants of all ages. However, this was more pronounced among the older two decades of adulthood (i.e., 75–84, and 85 + years). The theme of 'desire' included two subthemes: (a) lack of desire, and (b) change in what is desired.

Lack of desire. Participants of all ages identified a lack of desire as negatively affecting participation over the previous 5 years. Participants, such as CR, often expressed that the lack of desire was rooted in laziness: "some of mine is laziness, I'll be honest, you just don't bother" (75–84 years). However, other participants discussed a lack of desire to participate in activity due to changing interests: "I think the interest in things has something to do with it, you may still be able to do it, but you don't want to do it anymore" (YO, 75–84 years). Some participants spoke of decreased participation in specific activities, such as social outings: "Even going out socially, I don't have the desire to go out on Fridays dancing because I'm not up to it" (EG, 65–74 years), productive activities: "house repairs, things that have to be done, I don't want to do them" (FY, 75–84 years), and active leisure pursuits: "it's too much bother to get up and go for a walk" (TF, 65–74 years). Consequently, participants experienced a decrease in various activities due to a general weakened desire to participate.

Change in what is desired. Participants in the two oldest decades of adulthood (i.e., 75–84 and 85 + years of age) indicated that the desire to participate in specific activities had changed over the previous 5 years. Some discussed changes in preferences in a broad sense, such a FY: "you might have developed more interest in some of your leisure activities therefore you might want to do them more than you did before" (75–84 years). This was the case for many participants who expressed a shift in desire

to participate more often in passive leisure activities: "I'm more happy just to stay home during the week. . . it's like after the whole day you're ready to just relax at night" (75–84 years). Evidently, this shift in desire translated into greater contentment with participating in home-based activities as expressed by CR who quoted her 82-year old friend: "one thing a week is all I care to do, I'm quite happy to stay home every night" (75–84 years). Evidently, participants within the two oldest decades of adulthood acknowledged that the desire to participate in activities had shifted toward home-based passive leisure activities, and thus affected one's overall pattern of engagement.

External influential factors

Engagement profiles of participants within all decades of older adulthood were affected by external influential factors. Within this theme three subthemes emerged: (a) family role, (b) finances, and (c) availability of direct support.

Family role. Participation in activity was thought to be affected by one's family role for participants in the younger two decades of older adulthood (i.e., 65–74 and 75–84 years of age). Specifically, participants identified that having a role as a grandparent had changed their engagement profiles over the previous 5 years. Some participants, such as CR, expressed an increase in family activities due to the time spent with grandchildren:

> We're involved with our kids a lot, we have nine grandchildren, and I choose sometimes to be around for those kids, I prefer that, I'm just loving the fact that we can be there for them. Sometimes I might not commit to something, I rather be there if the kids come. . . that's one of the reasons things have changed (75–84 years).

However, other participants identified a decrease in family activities because their grandchildren were now adolescences and did not require direct care. This concept was explained by FD: "some of my family time has decreased because I don't have to babysit as much, my granddaughters are older now, so I'm not called upon to put on the bus, take off the bus, that kind of thing" (65–74 years). Therefore, the role that participants held within their families had the potential to change engagement profiles depending on the participants' responsibilities as a grandparent.

Finances. Participants within the younger two decades of older adulthood (i.e., 65–74 and 75–84 years of age) identified finances as a factor that affected participation in activity. Some participants, such as DN, spoke of specific instances where one's financial situation dictated participation in activity:

> When we go out with my Red Hat Group we usually go to either lunch or dinner. . . we have to be careful because everybody's on a fixed income and some of them really have to be careful, so we plan where we're going to go to eat that has to be reasonable (75–84 years).

The importance of finances to one's participation in social activities was further supported by OF in her response to why her social activities had changed: "money, if you're a widow you have to take care of money yourself" (65–74 years). As one would expect, financial security aided in the ability to participate in activity throughout older adulthood.

Availability of direct support. Engagement in specific productive activities was dependent on the availability of direct support for individuals within the older two decades of adulthood (i.e., 75–84 and 85 + years). However, this theme was more frequently and extensively discussed by those over the age of 85 years. The availability of direct support was associated with a decline of participation in specific productive activities as explained by FC: "I used to cut my own grass and now I don't, snow shoveling and all that kind of stuff, I have to have all that done" (85 + years). A participant, FC, explained the importance of the direct support she received from her family as it allowed her to stay in her own home: "been [at home] for over 50 years, if it wasn't for the kids I'd have had to go into some other place but they come by and anything I need they get, take care of me, so I'm blessed" (85 + years). Taken together, participants within the oldest decades of adulthood experienced a decrease of participation in specific productive activities over the previous 5 years if direct support was available to complete such activities.

DISCUSSION

This study presents a multidimensional examination of 'how' and 'why' engagement profiles change throughout older adulthood. Changes in engagement were examined through the frequency of weekly participation (in days per week) across four activity categories, with reasons for these changes being explored using focus groups and semi-structured interviews. Previous work identified that an active engagement in life was a principle component of aging successfully (Carr and Weir, 2017), which was reflected in participants' maintenance of engagement in personally meaningful and enjoyed activities in the current study.

The direct comparison of changes in participation across activity categories is a novel contribution to the existing literature. Overall, the greatest amount of time was devoted to participation in passive leisure activities, while the least amount of time was spent engaging in productive activities. Additionally, frequency of participation in both social and active leisure activities was similar in the past (5 years ago) and present. The pattern of increased frequency of participation in passive leisure and social activities is supported by previous literature (Gauthier and Smeeding, 2003, 2010; Victorino and Gauthier, 2005; Krantz-Kent and Stewart, 2007), as these are activities preferred and most enjoyed by older adults (Fricke and Unsworth, 2001; Nilsson et al., 2006; Chilvers et al., 2010). Many previous studies combined data across decades of older adulthood, thereby not allowing direct comparisons or the ability to identify points in time where activity patterns changed. The current data extend the previous literature by demonstrating that the frequency of engagement in productive and passive leisure activities differed across the separate decades of older adulthood ('age' variable), while there were no age-related differences in participation frequency for social and active leisure activities.

Each activity type was individually examined to provide more granularity of changing engagement patterns. Participants

consistently reported decreased participation in productive activities over the previous 5 years, as well as across the three decades of older adulthood, with the 65–74 year-old participants maintaining the highest level of participation. As supported by previous research, participants reported decreases in specific activities such as volunteer work, care for others, home repairs, and heavy housework (Johnson and Schaner, 2004; Fast et al., 2006; Krantz-Kent and Stewart, 2007). Previous literature suggests that domestic activities are maintained at a higher participation rate than other productive activities (Gauthier and Smeeding, 2003; Krantz-Kent, 2005), however, this was only true for light housework.[2] Caring for others, a specific productive activity, was influenced by one's responsibilities and enjoyment surrounding the care of grandchildren. If grandchildren required direct care, then patterns of engagement were shifted to incorporate this responsibility, thus *increasing* time spent in productive activities for some individuals. However, participants more commonly identified reasons for *decreased* productive participation, which corresponded to the quantitative findings. For example, the presence of health and physical limitations left participants feeling incapable of continuing such activities, while a sense of freedom from past priorities and a lack of desire to participate supported older adults in choosing preferred engagement activities. In addition, if participants had support to complete productive activities they were content to have others do them, yet still receive the benefit as these activities are typically outcome-based (i.e., cutting the grass; Maier and Klumb, 2005).

The other category that experienced an overall decrease in participation was active leisure, with changes evident across a 5-year time frame ('time' variable). This finding supports the limited research available, which suggest leisure time physical activity declines with age (Crombie et al., 2004). Not surprisingly, participants reported walking and gardening between one and four times per week as the activities they participated in most frequently, thereby supporting that most older adults are not meeting recommended guidelines for participation in physical activity (Ashe et al., 2009). Despite the lack of difference among the three decades of older adulthood, participants indicated that unspecified and specified health issues *decreased* active leisure participation. In contrast, other participants stated that remaining and/or becoming physically active was a necessity to overcome or manage these health-related issues, consequently, *increasing* active leisure engagement. This supports the notion that participating to receive health benefits, or to mitigate health limitations, acts as a stimulus for engaging in physical activity (Cohen-Mansfield et al., 2003; Mathews et al., 2010). However, this was only recognized by participants in the youngest decade of older adulthood (i.e., 65–74 year olds). As such, it may be beneficial to use this change in activity participation as a model to promote engagement in active leisure activities for all older adults, as health can evidently be both a barrier and a motivator to participate in physically active leisure.

Participants reported that the frequency of engagement in social activities throughout the decades of older adulthood remained stable. However, preference for specific social activities was impacted by participants' individual desires, experiencing the death of a friend and/or spouse, and financial constraints. A lack of desire was often grounded in laziness, supporting the notion that (dis)interest often dictates engagement (Crombie et al., 2004; Agahi et al., 2006). Those who had lost friends and family members spoke of a loss of social network, and an increasing desire to stay at home (Bassuk et al., 1999; Andrew, 2005), while widowed participants voiced feelings of social isolation and a reduction in overall activity (Strain et al., 2002). Despite frequency of social participation being maintained, findings suggest an increase in desire and contentment to participate in home-based, passive leisure activities over the previous 5 years of older adulthood (Gauthier and Smeeding, 2003). This supports quantitative findings that identify the social activities with the most frequent participation are those engaged in within a home environment including family/friendship activities, speaking on the phone, and visiting. As such, types of engagement activities may reflect a preference for activities based on the perceived enjoyment of the specific activity (Fricke and Unsworth, 2001; Nilsson et al., 2006; Chilvers et al., 2010). Furthermore, financial constraints may influence participation in specific types of social pursuits, as group activities can be expensive for individuals with modest, fixed incomes.

Similarly, stability of engagement frequency in passive leisure activities was reported. This contradicts the literature that suggests participation in passive leisure pursuits increase with age (Krantz-Kent and Stewart, 2007; Statistics Canada, 2015). However, the present study employed unique methods to examine changes in passive leisure engagement through cross-sectional and retrospective data providing an opportunity for semi-longitudinal trends to be examined. As previous studies have relied solely on cross-sectional data, the current study adds a unique perspective by indicating stable patterns of engagement over a 5-year period within the same individual. Additionally, this study defined passive leisure using Maier and Klumb's (2005) definition of discretionary activities that are chosen based on one's preferences and/or abilities. Other studies had broader definitions of leisure that included social, passive leisure, and active leisure activities combined, or that incorporated regenerative and/or personal care activities, such as sleeping or eating (Gauthier and Smeeding, 2003; Krantz-Kent and Stewart, 2007). Therefore, it may be appropriate to speculate that reports of increased participation in passive leisure activities may be confounded by the addition of personal care activities. Taken together, the evidence supports that older adults across three decades of older adulthood remain involved in a wide range of activities on a weekly basis. In fact, 100% of participants engaged in at least one activity from each category (productive, social, active leisure, passive leisure) between one and four times per week. It is, however,

[2]One of the challenges in interpreting the published literature is that definitions of activities are not consistent. Productive activities have been defined conservatively (e.g., paid/volunteer work, caring for others; Rowe and Kahn, 1997) and liberally (e.g., paid work, housework, active pursuits; Gauthier and Smeeding, 2003).

important to note that the participant sample included community dwelling older adults who were mostly recruited within public locations. As such, the sample represents individuals who have maintained a connection with the local community, and may not reflect all levels of physical and cognitive functioning, residing within communities that have differing resources, or common engagement practices of various cultures.

Overall, the lay-based conceptual model of successful aging supported engagement in life as a primary element required to age successfully (Carr and Weir, 2017). While participants experienced decreased engagement in productive and active leisure activities, participants likely continued to consider themselves 'engaged' as participation in social and passive leisure activities remained stable throughout older adulthood. Furthermore, engagement was maintained despite health-related issues and physical limitations, which supports aging successfully as a continuum where specific criteria are achieved, rather than a dichotomous label (Bowling and Dieppe, 2005; Baker et al., 2009; Young et al., 2009).

The concept of 'adaptation' (discussed in Carr and Weir, 2017) coincides with successful aging literature that emphasizes the importance of selection, optimization, and compensation to ensure well-being into older adulthood (Baltes and Baltes, 1990). Burnett-Wolle and Godbey (2007) hypothesized that if health status and physical functioning impacted leisure time activities, optimization and compensation may permit older adults to maintain participation in an adapted fashion depending on how meaningful the activity was to them. Thus, it is speculated that *how* and *why* engagement profiles change throughout older adulthood is reflected within this theory. For example, a decrease in productive and active leisure participation may be a result of the lack of meaning associated with personally completing such activities. Rather, older adults may prefer to optimize the use of internal (i.e., energy) and external (i.e., finances) resources to engage in activities that are found to be more meaningful, such as participating socially. In addition, older adults also encompass the resource of 'freedom' and thus can alter engagement profiles according to their abilities and desires, which often included passive leisure pursuits. Ultimately, the overall engagement profile of an older adult may be the result of the individual selecting to participate in activities that are meaningful and appropriate for their abilities and desires, which would result in greater enjoyment during such activities. Therefore, older adults are compensating by altering their engagement patterns with increasing age to ensure the maintenance of active participation, and thus successful aging.

Practical Implications

Integrated, evidence-based knowledge of 'how' and 'why' patterns of engagement change throughout older adulthood is a practical tool for both practitioners and policy makers. Establishing rationale for engagement changes in later life, as illustrated in the qualitative inquiry, provides contextual understanding to frequency changes, as depicted through the quantitative data. Such an understanding highlights that changes to frequency of engagement need not be considered solely an adverse adjustment associated with the aging process. For example, while the decrease in productive activity with age is not surprising given the health-related challenges associated with older adulthood, the decrease may be beneficial if viewed as a welcomed change. By minimizing time spent engaging in productive pursuits, older adults have the option to pursue activities that evoke greater enjoyment. Furthermore, reducing productive activities does not minimize the benefit to the older adult, as Maier and Klumb (2005) suggest that the benefit of the productive activity is the outcome (i.e., a prepared meal, a cleaned house), which can be obtained through the task being completed by a third party. Such cessation of productive activity may, in fact, preserve or enhance well-being as older adults choose to allocate personal resources to more meaningful engagement activities suitable for one's abilities (Burnett-Wolle and Godbey, 2007). By subscribing to these positive notions related to engagement changes in later life, practitioners and policy makers can frame promotional materials, resources, and programing within this understanding of favorable adaptations.

Similarly, older adults experience a decline in the frequency of participation in active leisure pursuits, which was described to be a consequence of health issues and physical limitations, as well as a lack of desire to engage in such activities. These data, however, provide practical applications for mitigating such loss of activity. First, health issues and physical limitations stimulate participation in active leisure activities among adults 65 to 74 years of age. By equipping practitioners with knowledge of active leisure activities suitable and appealing for adults 75 years of age and older, as well as ensuring the availability of appropriate programing, the onset of health issues and physical limitations may be framed as a motivator to increase active leisure pursuits for the associated health benefits among adults 75 years of age and older, as was the case for those in the younger decade. Second, by realizing the stability of the frequency of engagement in social activities throughout older adulthood, there is potential to use the desire and preference for social engagement to increase active leisure activities. For example, by promoting practical changes such as walking with friends rather than visiting within one's home, or having social programing that includes physical activities, an older adult may be more likely to choose active pursuits that also fulfill one's social desires.

As with social activities, frequency of passive leisure engagement was stable throughout older adulthood, with both activity types being identified as more desirable with increasing age, and an activity of preference when given freedom of choice and time. However, participants qualitatively identified an unwanted decrease is social engagement coinciding with the death of their spouse or friends. Recognizing this engagement change as unwelcomed, yet inevitable with increasing age, it supports the need to develop social groups and programing for bereaved spouses, or those seeking new social connections in later life. In doing so, social engagement may more likely be maintained, as desired, for those experiencing death of loved ones.

Taken together, engagement profiles of older adults continue to adapt and evolve through the aging process. Despite changes, all participants maintained engagement in at least one activity

within each of the four activity categories throughout older adulthood. This represents a well-rounded aging experience that includes rich forms of engagement, and an activity profile that is shaped by the individual.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Windsor Research Ethics Board. 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.

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"You Can Sit in the Middle or Be One of the Outliers": Older Male Athletes and the Complexities of Social Comparison

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Sporting events for older adults are proliferating in both popularity and participation numbers, mirroring the growth that is occurring globally with an aging population. Preliminary evidence indicates that older athletes have a tendency to compare themselves (in terms of their performance, participation, and aging) to inactive older adults deemed "worse-off." Our aim was to examine the stories and experiences of older, male Masters athletes, not only in terms of their own lives and in relation to others but also in the broader context of current (neoliberal) policies that promote sport across the lifespan. We use social comparison theory to interpret our findings and highlight the strengths and limitations of social comparison as a psychological strategy. For this study, 17 male competitive athletes (age range from 70 to 90 years) who participated in either the 2013 or 2017 World Masters Games were interviewed as part of a larger project on the meaning of sport in their lives. Seven different sports were represented, and participants hailed from multiple countries. Within the interpretive paradigm, we used qualitative methods to interview each participant, analyze individual transcripts, and develop common themes across the data set to address the aforementioned aims. Our two major themes were, *Sport as social comparison: "It's the competitive nature"* and *Downward comparisons*. A number of participants commented on the nature of sport, and competitive sport in particular, as being important to their motivation to train and prepare. Within the theme of *Downward comparisons*, we established two categories: *Resisting loss* and *Assigning blame*. While downward comparisons were used by our participants to separate themselves from other seniors of the same age, thereby bolstering their sense of self, participants also tied those comparisons to neoliberal notions of individual and moral responsibility for health. Participants believed that compromised health was due to individual negligence and bad decisions, with little reference to uncontrollable factors, such as non-modifiable risk factors for disease, disability, and/or socioeconomic status, which could be affecting people's lives or decisions. Ultimately, our findings show that the useful psychological strategy of social comparison for maintaining a positive sense of self and performance may also have some negative individual and societal consequences.

Keywords: Masters athletes, competition, role models, aging, qualitative research, sport promotion

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INTRODUCTION

> "It put me upon reflecting how little repining there would be among mankind at any condition of life, if people would rather compare their condition with those that were worse, in order to be thankful, than be always comparing them with those which are better, to assist their murmurings and complaining"—Daniel Defoe, Robinson Crusoe (Defoe, 1719).

Sporting events for older adults are proliferating in both popularity and participation numbers (Weir et al., 2010; Jenkin et al., 2017), mirroring the growth that is occurring globally with an aging population. Masters sporting events are an increasingly common form of later-life leisure, although older adults are still vastly underrepresented compared to other age groups in both physical activity levels (Troiano et al., 2008; Statistics Canada, 2015; Gomes et al., 2017) and sport participation statistics (Canadian Heritage, 2013; van Uffelen et al., 2015; Eime et al., 2016).

Masters athletes are individuals who take part in age-defined events in which competition is normally delimited by 5- or 10-year age groupings. The age at which one becomes eligible is sport specific; for most sports, one can participate at the Masters level after the age of 25 or 30, and it is not uncommon for athletes to compete into their 80s, 90s, and even over 100 years of age (Pfister, 2012). Masters sport has experienced explosive growth in recent years (Weir et al., 2010; Gard et al., 2017). The World Masters Games (WMG), for example, is a quadrennial event that started in 1985 in Toronto, Canada with approximately 5,000 participants (Weir et al., 2010). It has grown to the point that it is the largest multisport event in the world, typically hosting 20,000 to 30,000 athletes (International Masters Games Association, 2016). To put this in context, the 2016 Summer Olympic Games in Rio, Brazil had approximately 11,000 athletes competing (International Olympic Committee, 2018).

Masters sporting events, and their participants, are challenging long-standing notions about what is possible in later life in terms of human performance and leisure interests. It is often assumed in the exercise sciences, media, and policy that sport participation in later life is a positive example of modeling human potential across the lifespan, which should be celebrated and promoted to all, especially in developed countries (Coakley, 2015; Gard et al., 2018). However, our preliminary work (e.g., Gard et al., 2017; Horton et al., 2018) has revealed a moralizing component to Masters sport, such that it appears to cue the denigration of less physically active older adults who are often "blamed" for burdening the health care system. This way of thinking aligns with economic efficiency and individual responsibility for health, which underpins what has been termed a neoliberal shift in sport and health policies and promotion (see Gard et al., 2017 for a discussion of such research)[1]. This shift sees sport being used as a tool in social policy to help solve population health issues (see Gard and Dionigi, 2016). To critically examine assumptions surrounding sport in later life and to build on previous findings, our aim was to understand the stories and experiences of older Masters athletes (of their performance, participation, and aging), not only in terms of their own lives and in relation to others but also in the broader context of current (neoliberal) policies that promote sport across the lifespan[2]. We used social comparison theory to interpret our findings and highlight the strengths and limitations of social comparison as a psychological strategy.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Currently, there is a small, albeit growing, body of literature examining Masters athletes from biomedical and psychosocial perspectives. However, qualitative research specific to the psychosocial experience of sport participation for older adults is limited relative to that in the biomedical and quantitative domains. From a biomedical perspective, Masters athletes have been regarded as exemplars of aging success or models of human potential (Hawkins et al., 2003; Cooper et al., 2007; Louis et al., 2012). For example, older strength and endurance-trained athletes often measure superior to their age-matched, less-active peers on physiological characteristics such as muscle mass (Wroblewski et al., 2011) and maximal oxygen uptake (Trappe et al., 2013). However, the lens of biomedical aging success (i.e., Rowe and Kahn, 1987, 1997) has been frequently critiqued for taking a narrow focus on what constitutes happiness and satisfaction in later life, especially considering its relative neglect of subjective aging experiences (Glass, 2003; Martin et al., 2015; Martinson and Berridge, 2015). In response, Geard et al. (2017) proposed a more multidimensional model with which to view aging success, incorporating physical, psychological, cognitive, and social functioning criteria. Based on their review, the authors suggested that Masters athletes may represent this more broad definition of successful aging.

In addition to the physical benefits of competitive sport, Masters athletes appear to receive unique positive psychological outcomes, such as motivation for goal-oriented, health-enhancing behaviors (Baker et al., 2010), positive cognitive outcomes such as mental flexibility (Pesce and Audiffren, 2011), and positive social outcomes such as a sense of community (Lyons and Dionigi, 2007). In addition, Dionigi et al. (2013) showed how sport participation can be used as a strategy to simultaneously resist, redefine, and accept the aging process. Although research examining the non-physical outcomes derived by Masters athletes is preliminary, it does suggest that those who compete in events like the Masters games derive multidimensional outcomes

[1]We use the term "neoliberal" with caution because we know it is a contested term in the literature. In this study, we are using neoliberalism to refer to the current and dominant economic and political discourse (or "a sort of stand-in term for the political-economic zeitgeist"; Peck, 2010, p. 14) that pervades all aspects of society "to the point where it has become incorporated into the common-sense way many of us interpret, live in, and understand the world" (Harvey, 2005, p. 3).

[2]For the purpose of this study, we are using Gard et al.'s (2018) definition of policy as a "catch-all to talk about a range of phenomena such as official government programs and statements, educational curricula, existing and proposed public health interventions, the pronouncements of experts, and even media commentary" (p. 69).

above and beyond what would be accrued from what might be considered more "traditional" exercise (Dionigi et al., 2011a,b).

A recent systematic review has advanced knowledge related to the psychosocial outcomes of older adults' sport participation (Gayman et al., 2017). Broadly, existing literature suggests competitive sport bestows older adults with aging-related, cognitive/perceptual, emotional, social, and motivational benefits (Gayman et al., 2017). However, due to a paucity of data, the authors were unable to conclude whether these benefits were solely related to participation in sport. What does seem to be clear is that the manifestation of psychosocial outcomes through Masters sport is complex and varied. Of particular importance to the current paper is the preliminary observation that older male athletes are likely to use participation in sport as a means of distinguishing and distancing themselves from perceived "usual agers" on the basis of physical abilities (Eman, 2011, 2012). This tendency demonstrates the broader inclination of older adults to compare themselves to those they deem "worse-off" for self-enhancement purposes (Lockwood et al., 2005). We were interested in this particular pathway that older male athletes tend to use to derive positive psychosocial outcomes from Masters sport and the resulting implications for the individual and society.

Social Comparison Theory, Aging, and Sport

The proclivity of individuals to compare themselves to others is well established (e.g., Festinger, 1954; Wills, 1981; Wood, 1989; Lockwood et al., 2005; Gerber et al., 2018). The social comparison process involves individuals evaluating their opinions and abilities with one another for self-evaluation, self-improvement, and self-enhancement purposes (Wood, 1989; Gerber et al., 2018). These motives may be influenced by the social environment and are multidirectional, such that individuals may compare "upward," "downward," or "laterally" (Wood, 1989; Gerber et al., 2018). Upward comparisons tend to manifest as an evaluation with a person or group perceived as superior or "better-off" (Wheeler, 1966; Collins, 2000; Gerber et al., 2018), whereas downward comparisons tend to manifest as an evaluation with a person or group perceived as inferior or "worse-off" (Wills, 1981; Gerber et al., 2018). Lateral comparisons are made with others who are perceived as relatively equal in status; however, the three-choice paradigm (i.e., upward, downward, and lateral comparison) is understudied relative to the two-choice paradigm (i.e., upward and downward comparison; Gerber et al., 2018). The degree to which one uses either an upward or downward comparison strategy may be explained by regulatory focus theory, which suggests individuals possess a promotion or prevention orientation (Higgins, 1997, 1998). Those with a promotion orientation tend to focus on pursuing positive and desirable outcomes, whereas those with a prevention orientation tend to focus on avoiding negative and undesirable outcomes. Furthermore, some individuals are simply more inclined to make social comparisons than others (Gibbons and Buunk, 1999; Buunk and Gibbons, 2007; Merriman et al., 2019). The degree to which one demonstrates a predilection to socially compare is termed social comparison orientation (SCO; Gibbons and Buunk, 1999).

Findings from a recent meta-analysis (Gerber et al., 2018) revealed that individuals are generally more likely to make upward rather than downward comparisons, and the response is typically a contrast and subsequent decrease in self-evaluation. Regardless of the direction of comparison, those who are being compared to may be conceptualized as "role models." Role modeling is rooted in social cognitive theory (Bandura, 1977), which emphasizes "vicarious experiences" as influential to one's attitudes, beliefs, and behaviors. Changing attitudes and beliefs about aging and sport may be an effective means through which to increase physical activity participation in later life (Sarkisian et al., 2005). Role models, whether positive or negative, have the potential to stimulate positive behavior change (e.g., adopting a "healthier" lifestyle) by altering others' attitudes and beliefs and motivating individuals to set and achieve goals (Morgenroth et al., 2015). In the context of one's health, individuals with a promotion focus have a tendency to compare upward and are often motivated to achieve relevant health characteristics of "positive" role models (e.g., a friend who exercises regularly and consumes a balanced diet; Lockwood et al., 2005). On the other hand, individuals with a prevention focus have a tendency to compare downward and are often motivated to avoid health characteristics of "negative" role models (e.g., a sedentary colleague with multiple chronic health conditions; Lockwood et al., 2005). Importantly, the mechanisms, variables, and outcomes of role modeling manifest differently based on setting (e.g., educational, occupational, and achievement settings) and role aspirant profile (e.g., gender, race, and age; Morgenroth et al., 2015). These nuances are critical given that role model research with a focus on the unique considerations among older adults is sparse, with the majority of work focusing on younger cohorts (e.g., Zirkel, 2002; Chlosta et al., 2012; Chen et al., 2013). Additionally, less is known about role models in the context of encouraging sport participation in later life, providing part of the backdrop for our current article.

There has been speculation that social comparison regulatory orientation will change over the course of one's life. Specific to health and aging, Lockwood et al. (2005) demonstrated that as people age, they exhibit a greater tendency to compare downward to those in perceived poor health states. This may be due to the fact that the priority of older adults gradually shifts from optimizing, to maintaining, and ultimately to preventing the erosion of skills, abilities, and health (Lockwood et al., 2005). During youth, individuals tend to compare upwards, looking to role models in anticipation of improvements and advancements (Heckhausen, 1997; Ogilvie et al., 2001), and it is widely acknowledged that young people benefit from having positive role models (Zirkel, 2002; Chlosta et al., 2012; Chen et al., 2013). For example, Chen et al. (2013) demonstrated that having supportive role models who help reframe stressors and promote optimism was associated with reduced cardiovascular risk among low socio-economic status youth. For seniors, however, loss prevention may be just as important as promotion (Lockwood et al., 2005); thus, the emphasis turns to preserving what they have, as opposed to focusing on further gains. For older adults, negotiating later life becomes more of a promotion-prevention balance, and they may benefit from

both positive and negative role models (Lockwood et al., 2005; Horton et al., 2008, 2013).

Downward comparisons in later life may have real psychological utility. Wills' (1981) basic principle of downward comparison states that, "Persons can increase their subjective well-being through comparison with a less fortunate other" (p. 245). In essence, by focusing on and comparing themselves to an individual less fortunate, one may feel more reassured and gratified with their own abilities (Wills, 1981; Frieswijk et al., 2004). This process can be fueled by negative affect, low self-esteem, ego threat, and/or declining status (Wills, 1981; Gerber et al., 2018). Downward comparison principles appear to be particularly relevant with respect to older adults who, one could argue, are a "threatened" population (Horton et al., 2007; Dionigi, 2015). That is, seniors will inevitably experience age-related changes across many dimensions in their lives, including health status. When these dimensions are particularly self-relevant, individuals are inclined to see themselves as superior to, and distinguished from, others by means of downward comparison (Wood, 1989).

Many Masters athletes regard sport and physical competence as integral to their identity, with those at the extreme preferring to die rather than be sedentary (Dionigi et al., 2013; Dionigi, 2017). This might help explain why Masters athletes tend to make comparisons to, and at times disparage, other seniors who they perceived as lazy, sedentary, and morally inferior (Gard et al., 2017). This disparaging is perhaps also a reflection of the internalization of negative aging stereotypes in Western society, such as later life as a time of poor health, loneliness, and dependency (Ory et al., 2003; Horton et al., 2007). The processes and outcomes of downward social comparison seem to be riddled with complexities, such that these strategies may result in both benefits and problematic consequences for individuals and society.

The targets of downward comparisons may experience threats to their well-being. Wills (1981) noted that, "People consistently select safe targets—groups or persons whom the dominant culture considers acceptable to derogate" (p. 246). In the context of the current sport and active aging promotion climate, the "dominant culture" may be understood as Masters athletes, whereas the "targets" may be understood as inactive older adults. Gard et al. (2017) argued that recent neoliberal "sport for all" policy trends, which use sport as a solution to population health issues, have led to a normalization of participation in high-level, strenuous, competitive physical activity in later life. In other words, these widespread beliefs about the benefits of sport participation for one's health are constructing societal expectations for older adults to regularly participate in sport and structured exercise for the health of the nation, which may lead to "othering" seniors who do not partake (Dionigi, 2017; Gard et al., 2017, 2018). Such policies potentially conflate the *efficacy* of sport and physical activity for improving one's health (of which there is considerable evidence) with the *effectiveness* of sport and physical activity promotion in increasing participation levels and improving "population health" (of which there is no clear evidence; see Weed, 2016).

If we ignore the personal, social, and circumstantial determinants of healthy behaviors, we fail to realize that many seniors lack the means, access, ability, and interest to participate in sport, exercise or regular physical activity (Phoenix and Grant, 2009; Dionigi, 2017). As a result of their non-participation, sedentary individuals are often viewed by active older adults, and in the media and policy, as a burden on society in general, and health care systems more specifically. If current sport policy and promotion trends continue, Dionigi (2017) believes these inactive "pariahs" may be further victimized, stigmatized, and medicalized, reinforcing feelings of guilt and self-blame in regard to health outcomes. Moreover, in a heightened cultural and political context of sports' utility across the lifespan, it is important to consider how Masters athletes, who often place such great importance on high levels of physical performance, will adjust psychologically when they inevitably succumb to age-related physiological limitations (Dionigi, 2016, 2017). Ultimately, it is important to deepen understandings of Masters sport participation in an attempt to maximize the positive and minimize the negative multidimensional psychosocial outcomes.

Recent evidence highlighted older female athletes' (aged over 70 years) derived multifaceted benefits from competitive sport, as well as their tendency to subtly denigrate those who do not participate (Horton et al., 2018). However, research specific to older male athletes in this regard is sparse. Gayman et al.'s (2017) systematic review examining the unique psychosocial outcomes of sport involvement in later life outlined five studies exclusive to older male athletes. Two were case studies; qualitative interviews with an 88-year-old American runner (Roper et al., 2003) and a 68-year-old American tennis player (Langley and Knight, 1999). The remaining studies examined primarily psychological outcomes of older males' participation in competitive tennis, including locus of control and achievement motivation (Rotella and Bunker, 1978); collision avoidance skill, perception, and knowledge of action capabilities (Lobjois et al., 2008); and coincidence-timing, performance, visuomotor delay, and ability to adapt to changes in stimulus velocities (Lobjois et al., 2006). Four studies in Gayman et al.'s (2017), review included both men and women, one of which (Eman, 2012) highlighted the tendency of older male athletes to make comparisons with those that they perceived as less physically capable. Given this observation, and observations made in our previous work (i.e., Gard et al., 2017; Horton et al., 2018), we considered it important to explore this particular aspect of the male experience. The extent, frequency, and somewhat unsympathetic nature of the older men's social comparisons were noteworthy. Social comparison theory permitted us to scrutinize the male experience in this particular athletic and socioeconomic context more thoroughly, as well as highlight the negative implications of downward social comparisons by contextualizing the study within the concept of neoliberal health policies. Notably, the men in Eman's (2012) study were from Sweden and primarily involved in track and field, swimming, and skiing. Advancing knowledge and informing stakeholders of the psychosocial aspects of Masters sport from the perspective of a broad range of participants who vary in age, nationality, and chosen sport is timely.

Study Aims

This article focuses on interviews with older male participants in the WMG, which is part of a larger study on the meaning of sport in the lives of older adults (see Gard et al., 2017; Horton et al., 2018). Our focus for this article was in examining the data specific to how athletes spoke about their own sport participation, not only in terms of their own lives and in relation to others but also in the broader context of current (neoliberal) policies that promote sport across the lifespan. To that end, we investigated the thoughts, feelings, and attitudes of a particular group of older adults who were not the focus of our publications cited above – male Masters athletes aged 70–90 years – toward their own physical performance, participation, and aging. We use social comparison theory to interpret our findings and highlight the strengths and limitations of social comparison as a psychological strategy. The findings are intended to contribute to a more in-depth understanding and informed discussion of the psychological ramifications and the societal implications specific to how older adults view performance, active aging, and sport participation, thereby contributing to the literature across sport psychology, health promotion, and public policy.

METHODOLOGY

Research Paradigm

This study was broadly situated within the interpretive paradigm and used qualitative methods to make sense of the multiple and subjective meanings that people brought to their experiences and social world (Denzin and Lincoln, 2008). Specifically, social comparison theory was used as our guiding framework for interpreting the findings in this qualitative study. We drew broadly on the seminal works of several foundational theorists in the field (Festinger, 1954; Wheeler, 1966; Wills, 1981; Wood, 1989), were informed by Gerber et al.'s (2018) meta-analysis on social comparison research, and guided by Lockwood et al.'s (2005) work on age and health-related regulatory orientations within the social comparison paradigm (as detailed above). Lockwood et al. (2005) is particularly relevant given their emphasis on health and aging, allowing us to examine the complexities of social comparison among Masters athletes in the wider health promotion context.

Qualitative research, with its focus on human subjectivity, is sensitive to the complex experience of aging, sport, and society (Dionigi, 2006, 2016; Phoenix and Grant, 2009; Phoenix, 2018). To our knowledge, no study has qualitatively examined the stories of older male athletes specifically framed within social comparison theory and with consideration of the broader health promotion context. Therefore, we employed semi-structured interviews and purposive sampling to collect data, followed by an analysis and interpretation of data to address our aims.

Reflexivity Statement

As authors, we recognize that participants attach multiple, dynamic, and often contradictory meanings to their own aging. By listening to our participants' stories, we attempted to understand how active older men make sense of their lives, actions, and attitudes toward their sporting experiences. Participant responses were part of their personal, historical, and cultural context, and notably, so were our interpretations of them. All authors are long-term residents of Western nations (i.e., Canada and Australia), as were our participants, yet we are primarily middle-aged. We are all trained in the broad field of exercise and sport sciences, with more specific training in psychology and sociology relevant to the aims and scope of this study. Moreover, we each brought subtleties in our perspectives and approaches to the team, which allowed us to critically question each other throughout the research process (Smith and McGannon, 2018). This is particularly relevant given that we, as authors, were interpreting the words of our participants. As part of the qualitative approach and data analysis process, we have chosen certain passages to represent their thoughts and feelings, and we fully acknowledge our bias in that selection process. We realize that readers may interpret passages differently than the authors; thus, we have provided a number of verbatim quotations to not only justify our interpretations but also give the reader an opportunity to make their own meanings of the words participants have employed.

Participants

Participants for this particular component of our project were older, male competitive athletes who participated in either the 2013 (Turin, Italy) or 2017 (Auckland, New Zealand) WMG. Our previous work has used subsets of data from 2013 WMG participants (e.g., Gard et al., 2017 focused on men and women aged 60 years and over, while Horton et al., 2018 focused on women only). The present study adds to our ongoing project by presenting previously unreported data from the 2013 WMG, coinciding with the addition of data from the 2017 WMG and an explicit focus on social comparison theory and its implications among older male athletes.

Each participant was interviewed once, as explained below. We analyzed the interview transcripts of 17 male athletes ranging in age from 70 to 90 years. These participants were selected through purposive criterion-based sampling (Patton, 2002) based on specific criteria, including: age (70+ years of age), gender (male), language spoken (English), and competing in the WMG. Seven different sports were represented, which included badminton, basketball, lawn bowls, swimming, tennis, track and field, and weightlifting. Sixteen of the men identified as Caucasian, while one participant identified as Asian. Participants hailed from six countries: Australia, Canada, England, Germany, New Zealand, and the United States. As a group they were highly educated, although the range reported was considerable, from just a few years of formal education (i.e., elementary school) to a PhD. The majority were fully retired, with one continuing to work full-time and one part-time. Professions listed included civil servant, engineer, farmer, management, mechanic, physician, pilot, professor, teacher, and sales. Eleven indicated that they were married and four were widowers, whereas two did not indicate their marital status. Ethics approval was obtained from a University's Research

Ethics Board and all participants provided informed consent. In order to protect participant confidentiality, all were given pseudonyms for the purposes of data presentation.

Procedure/Interview Format

The first five authors of this article participated in the development of the interview protocol and conducted interviews at the respective 2013 and 2017 WMG events. We approached athletes at their competition venues to ask if they would be interested and willing to partake in an interview. The interviews themselves were conducted in a quiet space away from the sporting action, and we organized these interviews around participants' competitive schedules. A semi-structured interview format was utilized (Patton, 2002) which gives the interviewer the flexibility to probe participant responses for further detail. The topics included are sporting background/sport-life trajectory; training/preparation; motivation; competition; barriers to participation; role models; and thoughts on non-participation in sport and sports promotion. Examples of the questions we asked included: What role does sport play in your life? What is it about "competition" that attracts you? What inspires you (are you inspired by anyone? Do you have any role models?)? Why do you think many older people do not participate in sport? Interviews typically lasted from 30 to 60 min, although some lasted upward of 90 min. The ensuing dialogue was digitally recorded and subsequently transcribed.

Data Analysis

All authors were involved in the data analysis process. Specifically, the second and third author led the analysis of the 2013 data, whereas the first and last author led the process for the 2017 data. Together, the data were initially analyzed inductively to determine themes, which were then deductively interpreted using social comparison theory. That is, we used an inductive approach for the coding and analysis of the transcripts, where content-driven thoughts or ideas were identified as "meaning units" (Côté et al., 1993, 1995). Meaning units from different interviews (i.e., intratextually; Maykut and Morehouse, 1994) deemed sufficiently similar were identified and constantly compared against one another until main and secondary themes were established, and data become saturated to the point that nothing new was materializing in the analysis. Next, the themes were interpreted using the guiding framework of social comparison theory. Finally, the findings were discussed in the broader context of psychosocial and societal implications of sport and health promotion in later life, particularly as they pertain to neoliberal health policies.

Trustworthiness

Within the interpretive paradigm used for this study, several strategies were employed to ensure data trustworthiness, including triangulation to specifically enhance credibility. In particular, *analyst triangulation* was demonstrated by using multiple experienced qualitative researchers to interpret findings (Patton, 2002). While having more than one interviewer/analyst necessarily resulted in some variability in how the interviews were conducted and interpreted, every effort was made, through frequent quality control meetings and discussions among the research team, to ensure all of the key concepts were covered with each participant, and that consensus was reached on the themes. At the same time, interpretive research acknowledges that bias is inevitable because the "biographically situated researcher" is involved in every stage of the interpretive process and this reality should be embraced (Denzin and Lincoln, 2003, p. 30). During our meetings, we discussed the interview process, shared our experiences, questioned one another, self-reflected, and made slight adjustments when necessary. Moreover, purposive sampling was employed to address potential issues of transferability (Patton, 2002). We have attempted to clearly define our participants so that our verbatim quotes may be interpreted specific to older male athletes in relation to the context in which the data collection occurred and not necessarily generalized beyond the sample.

FINDINGS

Two major themes emerged in the analysis: *Sport as social comparison: "It's the competitive nature"* and *Downward comparisons*. Within the theme of *Downward comparisons*, we established two categories: *Resisting loss* and *Assigning blame*.

Sport as Social Comparison: "It's the Competitive Nature"

A number of participants commented on the nature of sport, and competitive sport in particular, as being important to their motivation to train and prepare. This went beyond what they perceived more traditional exercise could provide, and participants talked about working harder than they might otherwise, with competition serving as the key motivator. Neil (74, weightlifting) described the benefits he derives specific to competitive sport: "Really, the competition gives me more of an incentive to work out, you have an incentive to keep your body in shape but I don't think I would do it to the level that I do without competition." We also asked participants why they think Masters sport is growing in popularity. In response, Wayne (76, tennis) compared the adrenaline rush he gets from sport to a drug.

> I think people are realizing that the potential to be bedridden is there. I think the heart attacks are also there, and so on. I think they're starting to realize…and every heath professional will tell you that active sport is the way to go. So, I also take up dancing, and that's very enjoyable. It's very social as well. But sports give you the really head-on adrenaline that you can't get from other drugs.

Nathan (75, swimming) distinguished between "serious" swimmers who compete and recreational or "fitness" swimmers, drawing a sharp line between the two in terms of their approach in the pool. Here, we begin to see how a competitive context allows for and promotes social comparison.

> For me, the competing really makes me work harder, and it makes you do it right. I see a lot of fitness swimmers, and they make illegal turns. They make "short turns" occasionally, which you just don't do if you're serious.

Nathan clearly felt that competitive swimming not only makes him work harder but also enforces discipline that recreational swimmers forego. He went on to say that there is something very different about people who participate in competitive sport and that it is fundamental to their make-up.

> Some people just don't ever seem to want to compete. They are just not made to compete. For me, it's something I want and like to do. I suspect you must hear something like that from most of the people that are serious competitors. It has to be…A lot of people don't want to do that. I have tried to convince people that I swim with who don't compete that they should try competing. I get almost NO takers, it just doesn't happen…They just don't have this internal drive.

In this way, Nathan discriminates between competitive athletes and those who, for whatever reason, do not want to partake in competitive sport. Consequently, there appears to be a form of denigration at work, as he laments their lack of "internal drive," without any recognition of factors outside of their control, such as (dis)ability, socioeconomic or health status, or cultural background, which could be affecting their lack of participation.

Other participants talked specifically about winning. That aspect of competitive sport, establishing winners and losers, and keeping score, was an important component to them. Ian (70, badminton) explained that "it's the competitive nature, when you play sport the competitive nature is what motivates you, and you are always wanting to win." Davis (70, basketball) noted that "I like to compete, so I'm always ready to count score. I have to count score." In a more general sense, we see this from Barry (87, swimming), who compares his athletic prowess to others, and the positive effect that has on him. "I get a thrill, I get an urge of increased thoughts about myself, thinking that I can do this where others perhaps cannot and I relish in the effort of staying young." It appears that Barry's "increased thoughts" bolster his sense of self through direct comparison to others, which was a common feature of participant responses, providing the focus of the second theme. Essentially, it is important to emphasize that Masters sport seems to provide a fertile ground for social comparisons, given it is fundamentally a competitive context. To the men in this study, participation is not enough, rather winning and pushing for a personal best are expected and respected, which can exclude those who do not share these competitive ideals. Therefore, this theme has shown comparison *within* the Masters sport context, whereas the next theme focuses on how athletes extended these tendencies by comparing themselves with the stereotypical "inactive" older person.

Downward Comparisons

This major theme was divided into two subthemes: *Resisting loss* and *Assigning blame*. Both of these subthemes consist of our participants juxtaposing their abilities and capacities with others of a similar age. Comparing themselves with others who were worse off was the dominant tendency and appeared to bolster their own sense of self. Inherent within this, downward comparison strategy was a subtle but unmistakable disparaging of those who do not engage in physical activity.

Resisting Loss

A striking aspect of this subtheme was not that participants extolled the benefits of sport and exercise, but the extent to which they paired that notion with how much better they are faring than other people their age. By remaining so physically active, they perceived that they are avoiding the quality of life declines that they associate with the majority of their peers. Participants often made explicit comparisons between their own health and activity levels with what most other people their own age were experiencing. This is expressed in a somewhat benign fashion by Neil (74, weightlifting), who noted: "The physical rewards are very great, I see so many people my own age that have difficulty getting around and it's very rewarding to feel better." Somewhat more critical was Lee (72, badminton), who distinguished between his approach and what others his age were doing.

> I don't want to go to an RV park and a bunch of old people are sitting around in a hot tub complaining about, "oh my aches and pains"…most of my time I spend with young people so at my club where I open up the gym and play there is nobody else my age so I compete with the young people.

There are two interesting meanings in this statement – that there is no one at Lee's gym his age to compete against, so he seeks out younger competitors and the stereotyping of low-income older adults with various ailments. Lee goes on to say:

> I think the physical and the fitness is the most important but I was just sitting there with my mixed doubles partner and I said "this is really nice to be here with a bunch of people who participate in sports and have an active mindset." I would hate to go to some old folks' retirement community and sit around and do nothing. I couldn't stand that.

Masters Games provides Lee with access to people who have a similar "mindset" with respect to sports and physical activity. Once again, he makes the comparison to what he sees as perhaps more typical of people his age – sitting around and doing nothing. That is, internal attributes, such as lack of motivation or drive, are being judgmentally assigned to those who do not participate in sport, which aligns with current sport promotion messages and related policies that assume everyone can play sport (e.g., "sport for all" philosophies

that underlie the International Masters Games Association; www.imga.ch).

Similarly, Mark (72, badminton) contrasts his life-long devotion to fitness with others who have not done the same, and the consequences he perceives to be associated with those choices.

> My aim was, all my life was to keep myself as fit as possible. I've seen too many, especially farmers give up farming at 60 or 65 and sit down and most of them only last a few years, they don't do anything and in less than ten years most of them have died off. I don't feel like dying just yet.

Mark compared his longevity directly with others he has known who retired, lived a sedentary lifestyle, and subsequently died. Marks's perception is that his active lifestyle has been the difference between life and death. This presupposes a considerable degree of control over one's aging process, and also insinuates that people are responsible for their own fate. Essentially, this assumption of choice, self-responsibility for health, and assigning blame for a premature death are key features in neoliberal health policies, which leads us to our second subtheme.

Assigning Blame

There are some distinct similarities between Mark's quote immediately above and what Nathan (75, swimming) states below. Nathan, however, is slightly more explicit in assigning blame and responsibility to those who are inactive and suffering health consequences as a result.

> I look at colleagues, who spent their whole life writing papers and doing research…They're either dead or half dead. They're struggling to even exist. They're the same age as me. I attribute [my good health] to the swimming, and the high level of physical activity.

Nathan draws a direct line between behavior and the consequences for health. His choices have led to one outcome, while his colleagues are suffering the consequences for their choices. The implication is that if they have not already died, their quality of life is severely compromised, and the reasons for that are simple and uncomplicated, much like the messages in current sport promotion campaigns that assume we can all "get off the couch" if we so choose (e.g., in 2018 Sport Australia launched "Move it AUS," which claimed that all Australians, regardless of backgrounds, ages, and abilities, should become physically active and move more often; https://www.sportaus.gov.au/media_centre/news/sport_australia_encourages_all_australians_to_move_it_or_lose_it).

This notion of individual responsibility gets extended, at least for some participants like Barry (87, swimming), to how people can expect to be treated by others in positions of power and authority. Barry asserted that "I think it's much easier for an administrator to shelve an old person who requires a lot more attention than it is to stand by the side of a currently physical athlete." Notably, the question that elicited this response from Barry was fairly general in nature, asking him about sport, older people, and participation rates. Thus, we considered this response to be somewhat spontaneous and noteworthy because he believed that he would be favored due to his status as an athlete. The fact that he is an athlete made him more worthy of care, at least in his own mind, than someone more sedentary, who is easier to "shelve," cast aside, or ignore. This sense of moral superiority appears to be shared by Sam (72, track and field): "There is a spectrum, in everything we do we sit on a bell curve; you can sit in the middle or be one of the outliers. I think for a lot of people the other options are easier." Sam considers himself to be one of those outliers, and that this is primarily a matter of will power and discipline. To Sam, being an outlier is a conscious choice, rather than the product of circumstances or luck. Through exerting his individual agency, Sam positions himself (rather than *being positioned*, crucially) on that bell curve. Yet again, participation is attributed to internal characteristics and individual choice, with little recognition of social privilege, and being an athlete is positioned as a moral obligation to age well.

Justin (90, swimming) was very explicit in emphasizing both individual responsibility and choice in determining one's health, and in assigning blame if and when things go wrong.

> I mean how could you, when you're given this beautiful thing called a body in which we live, how could you not look after it and exercise it? This body is the most complicated piece of biological machinery in existence, and it should be cared for. If you don't, then you don't deserve to have health. It doesn't take much to keep it healthy.

According to Justin, compromised health is primarily a choice; in the absence of exercise, you are going to get sick, and you deserve your fate. While downward comparisons are used by our participants to separate themselves from other seniors of the same age, thereby bolstering their self-esteem, they also tie those comparisons to individual responsibility for health, and that compromised health is due to negligence and bad decisions. Poor health is often characterized as a failure of character, and thus deserved, which aligns with neoliberal health policies and marginalizes those who do not have the means, abilities, or desire to make such choices.

We will conclude our findings with a quote from Wayne (76, tennis) who drew a very direct line between sports and health for seniors.

> They should be encouraged to play sports. If they are playing sports they are a healthier person. So the hospital bill is not great right? And you see the people in rest homes? Most of them have not played sports. They are sitting there in a dull room, they sit there all day. What fun is that?

DISCUSSION

It is evident that older male Masters athletes derive a range of unique opportunities and outcomes from their participation in competitive sport. The men in this study displayed a strong desire to train, compete, win, and optimize their performance and health. These traits appear to be common among Masters athletes across a number of studies (e.g., Dionigi et al., 2011a,b; Eman, 2012; Horton et al., 2018), and as a result, older sport competitors are often held up as "exemplars" of human performance and aging success (Geard et al., 2017). In this regard, Masters athletes are challenging common myths and stereotypes that position later life as a time of disengagement, decline, and frailty. As the stories of the men in our study supported, competitive sport also clearly presents a chance for travel, social interaction, and a sense of empowerment (Dionigi et al., 2013). Thus, our participants perceived that Masters sport is distinctively rewarding above and beyond traditional exercise. Common perceptions in Western society tend to align with this belief in the inherent value of sport (Coakley, 2015; Gard et al., 2017). Additionally, it appears that public policy and health promotion efforts have bolstered and encouraged a "sport for all" agenda based, in part, on these assumptions. For those who have the resources and desire to compete, there are undoubtedly good reasons for promoting sport. However, through a critical analysis of our participants' stories, within a framework of social comparison theory, we aimed to highlight the often-overlooked complexities inherent in Masters sport. In addition, we attempted to highlight the negative implications of downward social comparisons by contextualizing the study within the concept of neoliberal health policies.

Masters Sport as Fertile Ground for Social Comparison

Previous research has indicated that the highly social nature of sport and sport events largely contributes to its perceived utility (Dionigi et al., 2013; Gayman et al., 2017). This sentiment was certainly expressed by the participants in our study, like Lee, who enjoyed the company of teammates with a similar "active mindset." Moreover, the competitive aspect inherent in sport may be a particularly potent motivating force among older male athletes. Eman's (2012) interviews revealed that older male athletes overtly valued results and rankings. Similarly, the men in our study placed great importance on winning and keeping score as central to their drive to stay active through sport. Davis, for example, indicated he must keep score when playing basketball. We believe that this often-beneficial nature of competitive sport may also foster a powerful social comparison environment.

Gerber et al. (2018) reported that social comparisons are strongest when targets are local, personal feedback is received, and when comparers are primed to feel dissimilar. Viewed through a social comparison lens, Masters sport appears to possess these characteristics. Target immediacy describes the tendency for outcomes of comparison (e.g., self-evaluation) to be most pronounced when the comparison is made to others who are spatially and temporally proximal (i.e., local)[3]. Masters sport is an intimate environment where athletes compete against and work with one another closely. Moreover, these relationships are enacted in a context where results and feedback on performance are inherent and ubiquitous. Thus, the locality of others and the competitive environment are logically optimal for frequent and robust social comparison opportunities. The athletes in our study persistently emphasized the social and results-focused aspects of Masters sport, which often came through and were embedded in evaluations with other athletes, peers, and the general population.

When held up as exemplars of active aging (e.g., in the media, policy, and academic literature), Masters athletes are being primed with dissimilarity relative to stereotypically inactive older adults. Feeling dissimilar heightens contrasts of self-evaluation away from the target of comparison (Gerber et al., 2018). It was clear that many of our participants perceived themselves to be different than sedentary others which resulted in self-enhancing contrasts. Ultimately, we deduced that the proximity of targets in the feedback-oriented Masters sport context cued social comparisons *within* Masters sport, and this tendency segued into comparisons *beyond* Masters sport (i.e., the "general" older adult population) when primed with feelings of dissimilarity. However, further research is needed to support and/or refute these postulations.

Psychological Utility of Downward Comparisons

We have presented preliminary evidence and inferences that sport participation provides older adults with an opportunity to compare themselves to others in somewhat similar circumstances. This applies to a competition itself as measured by wins and losses but often to their age cohort more broadly beyond the sporting arena. Findings have indicated that it is important for some older athletes to see themselves as "better" and "healthier" than their peers, whether this is expressed in an implicit or explicit manner (Dionigi, 2017; Horton et al., 2018). Responses from our participants suggested they rely heavily on "negative role models" to bolster their own psychological mindset and sense of self. Specifically, the older men conceived of comparison targets who were sedentary and in poor health, such as Nathan's colleagues in academia and Lee's caricature of a low-income individual with an inactive lifestyle. Those perceived as "worse-off" appeared to provide motivation for our participants to avoid the ill-health and quality of life declines often associated with old age. Thus, responses indicated that a "prevention" mindset with respect to their health was prevalent, perhaps more so than a "promotion" mindset, supporting previous findings and theory among older adults (Lockwood et al., 2005; Horton et al., 2013). Specifically,

[3]Gerber et al. (2018) offer the following example in target immediacy and local social comparison information: "…although comparison information about other students at a university may have effects on a person's self-evaluation, those effects can easily be removed or muted by comparison information about the other students in one's dormitory, and those effects can be removed or muted by comparison information about the students in one's suite" (p. 179).

participant objectives related to stemming losses and minimizing aging-related health decline. While some participants had certain individuals who inspired them, or "positive role models," downward comparisons to negative role models were mentioned more frequently.

These findings and considerations underline the importance of age differences in social comparison and role model research. In general, individuals tend to make upward comparisons (in contrast to downward comparisons) in social comparison situations (Gerber et al., 2018). However, a lifespan approach to social comparison theory indicates potential nuance. From the perspectives of older male athletes, it appears negative role models provide a non-trivial source of motivation to initiate, sustain, and improve human performance and potential in later years. Although our findings were elicited from the stories of a narrowly defined range of individuals, we believe that there are implications warranting exploration in other cohorts and salient to discussions on sport policy.

The men in this study often acknowledged the "perils" of aging (e.g., declining health) and how they were motivated by sedentary others to mitigate these perils through sport involvement. Lockwood et al. (2005) noted that, "downward comparisons may be a more effective means through which older individuals can adjust psychologically to the aging process." (p. 386). Depending on the role model profile, upward comparisons may actually threaten individuals, reminding comparers of their "inferiority" (Ory et al., 2003; Lockwood et al., 2005; Horton et al., 2013). "Superstar" and "super-fit" role models perceived as possessing unattainable characteristics and success have been reported to discourage the adoption of healthy behaviors, rather than encouraging them (Lockwood and Kunda, 1997; Ory et al., 2003; Horton et al., 2008). Downward comparisons, on the other hand, may fortify the comparer's psychological mindset, serving as a reminder of their "superiority" and contributing to feelings of gratefulness (Wills, 1981; Wood, 1989). This, in turn, may attenuate any potential feelings of inadequacy, failure, and resentment of those more fortunate than themselves. In the context of the current push for everyone to be active as they age, downward comparisons may be effective at motivating positive behavior change and reinforcing healthy behaviors (Lockwood et al., 2005). Essentially, downward comparison targets serve as an illustration of the costs of poor lifestyle choices, providing the comparer with a roadmap of what not to do and encouraging healthy habits – a process implicitly expressed by our participants. Further, downward comparisons may also provide utility in the realm of anxiety and stress reduction (Wills, 1981) to a cohort (i.e., older adults) that shares feelings of threat and uncertainty about their current and future status (Horton et al., 2007; Dionigi, 2015).

While this research is still in its early stages, our findings support the observation that older adults have a tendency to make downward comparisons. Advocates might argue in favor of promulgating this strategy as an effective means to cope with aging and promote, maintain, and retain performances near the limits of personal potential. As Daniel Defoe indicated in our opening quotation, a sense of gratitude is enhanced by comparing one's condition to others who are worse-off. Notably, however, downward comparisons often contain subtle disparagement of others, and while this has been touted as a useful psychological strategy (e.g., Wills, 1981; Frieswijk et al., 2004; Lockwood et al., 2005), there may be problematic individual and societal implications (as detailed below) of comparing downwards.

Societal Implications of Downward Comparisons

Our participants often attributed the behaviors of their sedentary peers to internal characteristics rather than external factors. For example, Nathan generalized that older adults who do not compete in sport are lacking an "internal drive." There was a substantial lack of attribution made to sociocultural and environmental determinants of health and aging, which are well established in the literature (e.g., Kerr et al., 2012). The older men felt better about themselves by "othering" inactive members of their age cohort, potentially using an attribution error as their vehicle to do so. Inactive older adults were associated with the "threat" of old age, which allowed the Masters athletes to distance themselves from that threat. From a societal perspective, and in the context of neoliberalism (see Harvey, 2005; Peck, 2010), these psychological tendencies may lead to negative consequences including stigmatization, stereotyping, and blaming of older adults who are unable to, or simply choose not to, engage in traditional forms of physical activity. This potentially sets up an in-group (active) out-group (inactive) bias, in which those who are sedentary are denigrated for their lifestyle (Gard et al., 2017). Many older adults, due to personal, historical, and circumstantial complexities, will not enjoy sport and exercise nor will they desire to partake in these endeavors (Dionigi, 2017). Nonetheless, our participants, along with "sport for all" public policy messages, have insinuated that inactivity in later life is unacceptable (Dionigi, 2017).

More broadly, the stories of our participants align with current neoliberal policies that focus on individual responsibility for health (Gard et al., 2017). As a result, the individual is blamed when they experience poor health, regardless of sociocultural determinants that may have contributed to their circumstances. Dionigi (2017) lists potential concerns with an overemphasis on individual responsibility for healthy aging, including a heightened fear of age-related health declines, an expanding social gap between active and sedentary older adults, and potential reductions in welfare support for those in later life. As sport participation behavior normalizes, these neoliberal attitudes have been reinforced, and in a sense, have become state-sanctioned and part of official policy (Gard et al., 2017). In this context, our participants expressed a degree of moral authority that they believed their active lifestyles granted them. Justin, for instance, stated sedentary individuals do not deserve to be healthy. Notably, the backgrounds of our participants suggest several advantages in terms of ability and opportunity to take responsibility for a physically active and engaged lifestyle. That is, the older male athletes were typically educated, Caucasian, married, and possessed the resources to regularly participate in a costly and time-intensive endeavor (i.e., Masters sport). This draws attention to researchers' indications that dominant

health promotion messages in Western society are most relevant to those who have the backgrounds that our participants possessed (Nettleton, 2006; Gard et al., 2017). Thus, it is feasible that our participants' profiles contributed to their views being aligned with broader neoliberal health promotion discourses, which emphasize personal responsibility for health and aging, position keeping active as a moral obligation, blame those who are not active for the nation's rising health costs, and undervalue sociocultural forces that potentially influence "right" lifestyle choices. Therefore, we argue that while negative role models may serve as an effective means to preserve a positive sense of self for Masters athletes, there are distinct implications for those who are the targets of these downward comparisons.

The majority of men in our study placed high value on a "forever young" mentality, such as Barry who stated, "I relish in the effort of staying young." Declarations such as these plausibly lead to a heightened fear of aging and a fear of ultimately becoming part of this stigmatized group. That is, constant exposure, reference, and internalization of ideals of youthfulness contribute to the social construction and individual conceptualizations of aging as a process to be avoided (Muise and Desmarais, 2010). It is common for groups in Western culture, particularly those with individualistic values (as opposed to collectivist values), to subscribe to notions of biomedical anti-aging (Haboush et al., 2012), and in doing so, they may be narrowing the possibility and probability of aging well. The reality is that many of those who reach an advanced age will experience impaired health (e.g., 82% of Canadians 71 years of age and older reported at least one high-impact, high prevalence chronic health condition; Statistics Canada, 2016). Unless athletes die on the court or in the field of play – a wish expressed by some of our participants and Masters athletes in previous works (e.g., Dionigi et al., 2013) – ill health in old age is almost inevitable. Dionigi (2017) noted that heightened expectations for older adults to remain highly active in later life could result in a senior citizenry that has difficulty coping with an inability to participate when disease and disability inevitably strikes. This concern may be particularly true for older athletes, as they tend to be uniquely invested in their sport endeavors and perceive their athlete status as a key element of their identity (Gayman et al., 2017; Horton et al., 2018). Psychological adjustment may be a challenge for those who are forced to cease sport participation for any number of reasons, including injury, chronic health conditions, and/or financial limitations.

Common to the human condition is a propensity to build our sense of self by comparing to worse-off others (Wills, 1981; Wood, 1989). This is apparent in interpersonal everyday life and on a broader societal scale. The paradox of downward comparisons is that we often need groups to denigrate in order to feel good about ourselves. Instances of illogical in-group/out-group biases are widely available and draw attention to the noted denigration by Masters athletes (and society) toward inactive older adults. For example, our findings support Peck's (2010) claim that, in the context of neoliberalism, new class divisions can emerge (e.g., the Creative Class), or in our case, the class of active older adults, which can widen the gap between the "haves" and the "have nots" in society. Peck (2010, p. 212) argued that the problem with the Creative Class is that those in this class form "like-minded enclaves, with little concern for the wider social consequences" and often claim that anyone can rise to their level, ignoring barriers caused by social inequality (much like the active older adults did in our study). In terms of health and aging, the problem with such class divisions is that the inactive group (or "underclass") will be further marginalized and ignored in a neoliberal context which removes public funding and shifts the responsibility of aged care from the state to the individual (Gard et al., 2017). Further research on such emerging examples of social stratification within sport contexts and the associated implications is needed.

Particularly salient to the present time is the pervasiveness of social comparison through social media networks (Lee, 2014). Social media users are given ample opportunities to compare their circumstances with those of others through mediums that often lack important context. Those with a high tendency to compare themselves to others have been shown to experience negative psychological outcomes (e.g., poorer self-perceptions, lower self-esteem) after engaging in social comparisons on social media sites (Vogel et al., 2015). We theorize that Masters sport, like social media networks, provides a context that encourages social comparison. However, a key distinction is that older athletes appear to favor downward comparisons while social media users are disproportionately cued to compare upward (Lee, 2014; Vogel et al., 2015). Since upward comparisons have been found to result in deflating self-evaluations (Gerber et al., 2018), one may see the merit in comparing to those who are "worse-off." Importantly, we argue that downward comparisons are problematic too, not only to the comparer, but the target of the comparison. Sport has the potential to be a positive experience for older adults, however, its promotion may be problematic when it is viewed as a superior means of later-life leisure, a public health intervention, or as a panacea to combat the "burdens" of an aging population (see Dionigi and Gard, 2018).

CONCLUSIONS

This study elicited the perspectives of older male athletes on their participation in competitive sport. By focusing on the stories and experiences of sport participation among men 70 years of age and older, who represented multiple countries and played a number of different sports, the findings built and expanded upon previous work (e.g., Eman, 2012; Gard et al., 2017; Horton et al., 2018). In particular, our participants simultaneously resisted and reinforced aging stereotypes. These older male athletes indicated the uniquely competitive nature of sport, and their associated participation, as a key factor in achieving high levels of performance in later life as well as combatting pervasive notions of loss, decline, and disengagement in old age. Comparison target immediacy, personal feedback, and dissimilarity priming are fundamental to Masters sport. Downward comparisons represented the predominant comparison approach used by our participants to separate themselves from other, less active seniors of a similar age, thereby bolstering their sense of self. This may represent an effective strategy for older adults to adjust to their

own aging and feel grateful for both their enviable circumstances and their abilities. However, a useful psychological strategy for maintaining a positive sense of self may have some problematic consequences at a broader societal level. These comparisons often contained denigration toward inactive older adults and were tied to ideas about individual responsibility for health and the economization of health, such that participants felt compromised health was due to negligence and bad decisions. The "in-group" of active older adults perceived the "out-group" of inactive older adults as stereotypical agers who are burdening the health care system. Our participants tended to overlook a number of complex factors that may have contributed to their fortunate circumstances, a way of thinking that could lead to less societal support and personal empathy for the most vulnerable in society. Ultimately, we recognize the inevitability of social comparison and the various potential merits and drawbacks of both upward and downward comparison strategies. By shedding light on the complexities of social comparison in a group of male Masters athletes, we hope to stimulate further discussions across the fields of sport psychology, health promotion, and public policy in this context.

There are limitations inherent in this study. Notably, participants constituted a predominately Caucasian, highly educated, upper-middle class sample. Although this sample is consistent with the archetypal demographic profile of Masters athletes (Gard et al., 2017), future studies should solicit the views from a more diverse range of participants. It would be beneficial to compare the similarities and differences between typical and minority groups in this cohort. Moreover, garnering the opinions of non-athlete older adults on Masters sport will be important to more fully inform health promotion initiatives. This is especially true considering less active older adults are generally the targets of sport and aging programs (Gard et al., 2017). Most importantly, we encourage the continued gathering and mobilization of older adults' stories so that their voices may contribute to shaping directions for health policies, sport, and aging agendas, and modeling human performance across the lifespan.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the University of Windsor Research Ethics Board with written informed consent from all participants. All participants gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the University of Windsor Research Ethics Board.

AUTHOR CONTRIBUTIONS

SH, RD, MG, JB, and PW contributed to the conception, design, and data collection for the study. All authors were involved in the data analysis process. Specifically, RD and MG led the analysis of the 2013 data, while SH and JD led the process for the 2017 data. SH and JD wrote the first draft of the manuscript. All authors contributed to manuscript revision and read and approved the submitted version.

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MINI REVIEW
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Designing Junior Sport to Maximize Potential: The Knowns, Unknowns, and Paradoxes of Scaling Sport

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In this mini-review, we draw attention to an important yet relatively untapped topic in the developmental pathway – the design of junior sport so that it appropriately matches the functional capacities of children. Junior sport is a regular weekend activity for many children across the world, yet many will be required to prematurely play on a field or with equipment that is designed for adults. Herein lies an opportunity for sport administrators to nurture children's development in sport by appropriately manipulating the rules and dimensions of the game. The aim of this mini-review is to (1) draw attention to the value of scaling junior sport, (2) highlight paradoxes within the current scaling sport literature, and (3) emphasize a way forward for junior sport research. If we are genuine in our endeavor to tailor sports experiences for children, more sophisticated approaches to scaling those experiences are a must.

Keywords: modified sport, scaling task constraints, ecological dynamics, junior sport, skill acquisition, children's sport

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INTRODUCTION

Junior sport is a regular weekend activity for many children across the world. It forms part of contemporary junior sport participation products or programs, often targeted at children aged 10 U, or features as the (only) pathway for retaining children in the game whom are transitioning out of these junior sport products. Regardless of an individual child's introduction to sport, many will be required to prematurely play on a field or with equipment that is designed for adults. Should we expect the 10-year-old tennis player to experience success and remain in the sport when they cannot serve the ball into the service box on a full-sized court? What about the talented 12-year-old cricket player, who each week faces bowlers who find it difficult to land the ball on a full-sized pitch? Are these environments or experiences maximizing skill learning and engendering a love of the game?

Scaling sport is often perceived as merely an entry-level strategy to attract children into sports. As alluded to above, certainly there are examples of sports across the world that have grown their participation base on the back of modified programs that allow children to play the game with greater ease. However, at least three glaring issues remain with the design and implementation of modified junior sport: first, the rate at which its features or task constraints (ball size, field size, etc.) scale to the adult game is crude and arbitrary; second, many junior sport programs are facilitated or led by *coaches* while competitions are not; and third, a child's

exposure to sport in *what might be considered more appropriate* modified conditions is limited. Indeed, our systematic review highlighted that many sports require children to play in adult environments by the age of 10 (Buszard et al., 2016). Perhaps unsurprisingly, this coincides with a high dropout from sport during pre-adolescent years. For example, a longitudinal study of modified sport in Australia found that fewer than 25% of girls and 14% of boys transitioned from a (coach-led) modified sport program, designed for children aged 5–10 years, to club competitions that target players from 10 years of age (Eime et al., 2015). With this in mind, it is possible that sport authorities could better transition children into full-sized conditions by better scaling competition for some age groups and/or skill levels.

In this article, we critique empirical evidence that highlights the effect of scaled environments in junior sport. Indeed, the purpose of this mini-review is to draw attention to the potential value of scaling junior sport, while simultaneously highlighting the unknowns and paradoxes within the scaling sport literature. Although we recently published a systematic review on scaling junior sport (Buszard et al., 2016), we felt that it was important to highlight key issues to be addressed (that were not discussed in the systematic review) given the attention that is being given to modified sport within sport organizations. It should become clear that more sophisticated approaches to scaling junior sport are necessary if we are genuine in our endeavor to tailor sports experiences for children.

WHAT DO WE KNOW ABOUT SCALING?

A Brief Recap of the Scaling Literature

Scaling junior sport is not a new concept, but it has become popular over the past decade. Research began focusing on scaling in the 1960s (Wright, 1967), albeit in small doses (Elliott, 1981; Satern et al., 1989; Regimbal et al., 1992). It was not until the rise of formalized modified sport programs, which have predominately been developed based on intuitive reasoning rather than empirical evidence, that we have seen an exponential increase in the number of studies investigating scaling sport. By way of example, the International Tennis Federation's launch of the ITF Tennis Play and Stay Campaign – its modified tennis for children aged 5–10 years – was the impetus for Hammond and Smith's (2006) investigation of lower compression tennis balls for children aged 11 years and younger. This subsequently led to Farrow and Reid's (2010) study on ball compression and court size, and since then sport scientists and academics have examined its use in a range of sports, including tennis (e.g., Buszard et al., 2014a; Kachel et al., 2015; Timmerman et al., 2015; Fitzpatrick et al., 2017), basketball (e.g., Arias et al., 2012a; Arias-Estero and Cánovas, 2014; Arias-Estero et al., 2018), cricket (Harwood et al., 2018a,b, 2019), Australian football (Hadlow et al., 2017), and soccer (Sarmento et al., 2018). The following sections describe what we have learnt about scaling junior sport.

Theoretical Underpinnings

The rationale for scaling sport is predominantly underpinned by an ecological dynamics viewpoint of human movement and skill acquisition. Ecological dynamics advocates that an individual's behavior emerges from the self-organization of perception and action under interacting constraints (organismic, environmental, and task) (Araujo et al., 2006; Davids et al., 2012). Indeed, the constraints imposed by sport (e.g., field size, number of players, equipment, duration of match, etc.) determine the boundaries of what actions are possible (referred to as the *affordance landscape*) (Newell, 1986). Clever manipulation of constraints can therefore influence the emergence of skills and strategies that children can learn while maintaining information-movement couplings that are inherent to the sport (Fitzpatrick et al., 2018). Hence, by altering the constraints of a game (e.g., smaller tennis court) to match the functional capacities of the individual (e.g., small stature and minimal strength), the task is simplified and children are able to perform skills that are otherwise not possible (e.g., explore depth and width of the court with groundstrokes). Accordingly premise of scaling sport is to augment the development of skills that are considered desirable for long-term performance and retention in the sport.

Scaling sport also has theoretical support from the theory of implicit motor learning. Implicit motor learning contends that learning is more durable and robust when the learner acquires a skill without conscious awareness of the underlying mechanics (Masters, 1992). Often motor skills are learnt implicitly when errors have been reduced (referred to as *error reduced learning*) as this limits the need for the learner to consciously analyze and correct errors (Maxwell et al., 2001). Given that a key benefit of scaling sport is that it heightens success for children (Buszard et al., 2014a), it is reasoned that appropriate scaling will reduce any tendency for children to correct errors, thereby evoking a more implicit mode of learning. We attempted to test this hypothesis by assessing the acute effect of equipment on children's ability to perform a tennis task under dual-task conditions (Buszard et al., 2014b). We found that lesser skilled children performed significantly poorer under dual-task conditions when using full-sized but not scaled equipment. This suggested that there was greater conscious involvement when using inappropriately sized equipment. Indeed, this provided initial support that scaling equipment might promote implicit motor learning, but a learning study is required to consolidate this view.

The Junior Sport Experience in a Scaled Environment

A number of studies have examined the effect of scaling junior sport by assessing performance in competitive matches. These studies have typically compared performance in scaled environments with performance in full-size environments. Children who are beginners to tennis created longer rallies and experienced more success with serving when playing with lower compression balls on smaller courts (Fitzpatrick et al., 2017). Lower compression balls as well as lower net heights have also positively affected the competition experience of highly

talented children with more approaches to the net, more winners, and more successful serving (Kachel et al., 2015; Timmerman et al., 2015; Limpens et al., 2018). Similar themes have emerged in basketball, where a lighter ball has resulted in more dribbling and passing (Arias et al., 2012a), increased shot frequency and greater shot success (Arias et al., 2012a,b), a higher percentage of attempted lay-ups (Arias, 2012a), and more one-on-one situations (Arias et al., 2012c). Ultimately, when we modify or scale the constraints of junior sport, we are shaping children's sporting experience, and we are facilitating exploration. Certainly there is strong evidence to show that appropriate modifications can facilitate rather than confine the emergence of desirable actions and behaviors for children playing sport.

Skill Acquisition

Appropriate scaling of task constraints can facilitate the emergence of more desirable movement patterns. For example, beginner tennis players strike the ball more often with a low to high swing when using low compression balls compared to standard balls (Buszard et al., 2014a). Likewise, in cricket, 13-year-old fast bowlers displayed less shoulder counter rotation when bowling on shorter pitch lengths (Elliott et al., 2005). Significantly, shoulder counter rotation is linked with low back stress fractures – a common injury in junior fast bowlers (Elliott, 2000). In these examples, the assumption is that these coordinative patterns will become stable movement solutions with enough repetition. From a decision-making perspective, a shorter pitch length in cricket also increases the likelihood that children will make decisions when batting that are more similar to the adult game (Harwood et al., 2019). Specifically, playing on a shorter pitch increased the probability that children played short-pitch deliveries off the back foot rather than the front foot (a common feature of senior cricket). The implication is that children will learn to couple the action of playing a back foot shot when perceiving a short pitch delivery, and this will therefore augment development toward the adult game.

Unfortunately, however, few studies have examined the effect of scaled constraints on skill acquisition over a substantive period of time, with the intervention period often being short (e.g., 5 weeks). Nonetheless, these studies have revealed positive results regarding the effect of scaling on the performance outcome (e.g., sustaining a rally or hitting accurately) (Elliott, 1981; Farrow and Reid, 2010). Notably, Fitzpatrick et al. (2018) showed that children adapted to the constraints of the task over a period of 8 weeks. In this study, children were exposed to tennis tasks, including point-play akin to competition, but with the addition of specific constraints that aimed to shape behavior. For example, a recovery box location was positioned off center behind the court on the children's forehand side and children were asked to return to this box after every point. The resultant behavior was an increase in backhands being performed. Hence, within the context of weekend junior sport, children will likely adapt to the constraints of the game by exploring and adopting solutions that generate success while satisfying the task constraints. Over time, and with enough repetitions, these solutions will stabilize and develop into *learnt* behavior. Clever manipulation of constraints can therefore promote the emergence of new behaviors as children adapt to new task constraints. Indeed, exposing children to a variety of constraints in a random manner can promote movement degeneracy (Lee et al., 2014) – the ability to functionally complete a task with different movement solutions (Seifert et al., 2016), which is a characteristic of expert performers (Seifert et al., 2013). We therefore expect children's skill acquisition to be augmented when continuously exposed to environments that are appropriately modified.

FUTURE DIRECTIONS

Evidence clearly shows that concept of scaling junior sport can have a positive influence on children's sporting experience. However, despite our best efforts to unpack the design of scaled sport, there are a number of important questions that remain answered.

Should the Junior Game Look Like the Adult Game?

An implicit assumption of the scaling sport argument is the idea that the junior game should resemble the adult game with respect to match-play characteristics and behaviors. We assume that the preservation of important characteristics of the adult or professional game, *via* appropriate manipulations, affords the acquisition of skills important for the development of expertise. For instance, Kachel et al. (2015) argued that the lower compression green ball was superior to the standard yellow ball because rally speed was closer to the professional game and that this would lead to players learning to play the game more like adults. While this may seem intuitive, even necessary at some point in a player's journey toward the *adult* game, when and how this should happen remains uncertain. Put more bluntly, we do not actually know how closely the child's game should mirror the informational or spatio-temporal constraints of the adult game to augment their development. A combination of prospective and longitudinal experimental designs is required to solve this issue (Farrow et al., 2018).

Paradoxes in Our Thinking

Intuitively we assume that scaling should be based on one specific variable that reflects maturation, such as height. For example, Limpens et al. (2018) argued that the net height in tennis should be approximately 50% of children's height given that the full-size net height is about 50% of the professional tennis player's height. Significantly, this assumption implies that scaled environments should linearly progress toward adult environments. However, we know that skill acquisition is a non-linear process (Davids et al., 2008). Indeed, non-linear pedagogy, which is grounded in ecological dynamics, implies that skill acquisition is enhanced when the learning environment embraces non-linearity by promoting variability (Chow et al., 2011). This means that creativity in altering constraints can help to develop an adaptive movement system and reduce the risk of skill imbalances over time. The concept of non-linearity

can be interpreted to suggest that scaling guidelines should in fact follow a non-linear path, however this then raises the question of what scaling should be based on? Understanding this question will help sport administrators set guidelines for junior sport so that children's sport experience is maximized.

Another paradox in the scaling literature is the notion of repetition, skill, and injury (Reid et al., 2018). For example, modifying the ball and court in tennis was suggested to promote a positive learning experience due to the increase in repetitions when playing in such conditions. Intuitively, this is a positive outcome as more repetitions should lead to greater improvements in skill. However, taken to an extreme, could more repetitions also load musculoskeletal tissue in such a way that the likelihood of overuse injuries is increased? Sport scientists and medical professionals should collaborate to answer this question, as this will guide recommendations regarding volume of play in junior sport.

Engagement, Motor Competence, and Sustained Participation?

Scaling sport allows children to experience more success (Buszard et al., 2014a,b), which appears to aid greater engagement (Farrow and Reid, 2010) and self-efficacy (Chase et al., 1994; Arias, 2012b). By designing environments that promote opportunity for success, children are more likely to have a heightened perception of their own ability. This is significant as perceived motor competence is considered a precursor to engaging in sport and physical activity, and greater engagement improves actual motor competence (Stodden et al., 2008). Importantly, a cyclical relationship exists between motor competence and physical activity levels. Children who are more competent with their motor skills are more likely to engage in physical activity in adolescence (Barnett et al., 2009; Lopes et al., 2011). Hence, it seems reasonable to think that scaled environments in junior sport will heighten children's perception of their own ability, which will then lead to more participation in the sport, improved actual motor competence, and a greater likelihood of sustained participation.

CONCLUSION

Sports administrators have a unique opportunity to nurture children's weekly sporting experience by appropriately manipulating the rules and dimensions of the game. Equally important, however, are researchers and sport scientists to ensure that scaling is evidenced-based and grounded in theory. Indeed, it is evident that appropriate scaling can positively shape children's skill development, but there are still many unknowns that need to be addressed. These include (1) whether the junior game should mirror the informational or spatio-temporal constraints of the adult game, (2) whether scaling should be guided by a variable describing physical maturation and therefore follow a linear progression despite our knowledge of non-linearity in skill acquisition, (3) whether a by-product of scaling is a greater risk of overuse injuries due to increased repetitions, (4) and whether scaling positively influences the cyclical relationship between competence and physical activity. Addressing these issues will likely require more sophisticated approaches than currently adopted in the scaling sport literature, but in doing so we will help maximize the potential of all children, irrespective of age, gender, or skill.

AUTHOR CONTRIBUTIONS

TB wrote the first draft of the manuscript. MR and DF edited subsequent drafts. All authors contributed to manuscript revision, and read and approved the submitted version.

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