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Developmental activities of professional male British rugby-league players versus controls

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ABSTRACT

Purpose: Many rugby league clubs rely on developing youth athletes into experts in adulthood. One factor that contributes to the attainment of expertise is the activities that athletes engage in across their development. Therefore, the developmental activities of professional male British rugby league players were compared to lesser-skilled players.

Methods: Players who had progressed from youth academies to professional status, those who were released from youth academies, and those who had only played recreationally completed the Participation History Questionnaire.

Results: During childhood, professional players accumulated significantly greater amounts of play compared to ex-academy and recreational players, as well as greater coach-led practice compared to ex-academy. During early adolescence, this pattern continued, whereas in late adolescence the professional and ex-academy players accumulated significantly greater amounts of coach-led practice compared to their recreational counterparts. Professional players accumulated more hours in rugby league up to 18 years of age compared to ex-academy players, with both groups accumulating more hours than recreational. The number of other sports engaged in was relatively low across development and did not discriminate between performance levels.

Conclusion: Findings from this study may inform future practice of talent development systems within rugby league in Britain.

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KEYWORDS

Expert performance; talent development; skill acquisition; development pathways

Introduction

The development of youth athletes into experts in adulthood is the aim of many sporting clubs, national-governing bodies, coaches, and support staff. There are many factors that can contribute to expertise in adulthood (for a review, see Rees et al. 2016). One factor that contributes to the attainment of expertise is the amount and type of activities that athletes engage in across their development. Over the years, there has been considerable research in team sport athletes, particularly in soccer (e.g., Helsen et al. 1998; Ford et al. 2012; Hornig et al. 2016; Güllich et al. 2020a), yet little research currently exists examining the developmental activities of professional rugby league players. In the present study, we address this issue by examining the developmental activities of professional male British rugby league players.

Over the last three decades the deliberate practice theory (Ericsson et al. 1993; Ericsson 2013) has been instrumental in shaping understanding of expert athletes. Deliberate practice is characterised as effortful, coach-led, individualised activities that are aimed at improving a key aspect of performance that is near or beyond the current ability of the individual, also consisting of repetition and individualised feedback. Moreover, Ericsson et al. (1993) suggested that deliberate practice was not inherently enjoyable, although recent empirical work contradicts this hypothesis, at least for coach-led practice in sport which may not share all the characteristics of deliberate

practice (e.g., Güllich et al. 2020a). The deliberate practice theory proposes that the level of acquired performance level is monotonically correlated with the accumulated time in deliberate practice, where those that engage earlier and practice at higher amounts will have better performance levels throughout development than those that engage later (Ericsson et al. 1993). These ideas have led to greater specialisation in a single sport occurring in early childhood (i.e., 6–12 years of age) in attempts to maximise the time spent in 'deliberate practice' (Jayanthi et al. 2013).

Deliberate play is characterised as informal games-based activities led by the children themselves (e.g., pick-up games); with the overall intention being inherently fun and enjoyable (Côté and Hay 2002; Côté et al. 2007, 2012; Côté and Erickson 2015). Researchers have proposed an alternative to 'early specialisation' is that athletes sample multiple sports through extensive peer-led play in childhood, with little coach-led practice and specialisation in a sport occurring later. This more diverse engagement in sports has been suggested to reduce the costs and hazards associated with early specialisation, such as overuse injuries and dropout (Côté et al. 2007, 2009, 2012; DiFiori et al. 2014; Rees et al. 2016). However, the early specialisation and diversification pathways are two dichotomous patterns and do not fully explain the complexities of the developmental activities of expert athletes (Ford and Williams 2017; Güllich et al. 2020b). Childhood participation patterns can

be defined by several continuous variables that may vary independently from one another including start age, amount of sport-specific and other-sport coach-led practice and peer-led play (Ford and Williams 2017).

Retrospective recall methods based on the work of Ericsson et al. (1993) have been used to assess the developmental activities of athletes in which start ages and amounts of these types of activities are recorded via interviews and questionnaires. Researchers have used this method to investigate whether the activities of higher and lower performing athletes differ (for reviews, see Güllich and Emrich 2014; Hendry and Hodges 2019). Research groups have used *different* retrospective recall tools to measure activities in various samples of athletes that differ by sport, country, gender, and skill level, with many studies assessing athletes who are *not* professional or world-class. The variability in tools used, samples assessed, and the lack of meta-analysis or systematic review, make drawing firm conclusions from this body of work difficult. Güllich and Emrich (2014) concluded in their review that world-class athletes (Carlson, 1990; Johnson et al. 2006; Ronbeck et al. 2009) were differentiated from lower-skilled national-class athletes by greater participation in other sports during their youth, but not by engagement in their primary sport. Güllich et al. (2020a) reported in their review that in more recent studies the difference between world-class and national during their youth was in other sport coach-led practice (Güllich and Emrich 2014; Hornig et al. 2016; Güllich 2017, 2018, 2019). In contrast, they (Güllich and Emrich 2014; Güllich et al. 2020a) concluded that greater youth participation in the primary sport is correlated to national level attainment and junior success. Ford and Williams (2017) highlighted that world-class athletes in many studies (Carlson, 1990; Johnson et al. 2006; Ronbeck et al. 2009; Hornig et al. 2016; Güllich 2019) were engaging in significant amounts of their primary sport (e.g., tennis; Carlson, 1990) from childhood onwards. They stated it is not possible to retrospectively attribute causality for expert performance and its underlying mechanisms to any of these specific activity types.

Retrospective recall tools measure start ages in various activities. World-class athletes (Moesch et al. 2011; Güllich and Emrich 2014; Güllich 2017, 2018, 2019; Casado et al. *in press*) recorded slightly later start ages in their main sport compared to national athletes, whereas lower-level comparisons (i.e., national vs. regional class; regional class vs. below) have indicated that national athletes recorded earlier start ages (Drake and Breslin 2018), sometimes later (Memmert et al. 2010; Hendry and Hodges 2019; Casado et al. *in press*), or did not differ (Memmert et al. 2010; Roca et al. 2012; Coutinho et al. 2014; Hornig et al. 2016; Hendry and Hodges 2018) when compared to regional and lower-skilled athletes. There is a lack of research assessing start ages and youth engagement in sports activities in rugby league players, although other factors have been shown to differentiate career attainment level, such as players relative age compared to their peers in the selection year (Till et al. 2010) or anthropometrics and physical qualities (Till et al. 2016, 2017). However, two studies (Rothwell et al. 2017; Cupples et al. 2018) have assessed some aspects of youth engagement in sports activities in rugby league players.

Cupples et al. (2018) assessed the developmental trajectories of 224 male professional rugby league players in Australia. Players started in rugby league in childhood (7–8 years of age), specialised in the sport in adolescence (15–16 years of age), and made their professional debut in early adulthood (19–20 years of age). Two groups were categorised who either first entered higher representative teams between 16 and 18 years of age or slightly later at 19 years of age. Players engaged in 20–25 rugby matches per season in childhood (5–9 years of age) rising to 40–50 matches in early adulthood (17–29 years of age), with the earlier starters in youth representative teams accumulating slightly more matches in adolescence when compared to the later starters. On average, players engagement in rugby-specific practice rose from 2–3 hrs/wk at 5–9 years of age to 10–15 hrs/wk in late adolescence (17–20 years of age). In contrast, on average, hrs/wk in rugby-specific play activities decreased from 3–5 hrs/wk in childhood (5–12 years of age) to 2–4 hrs/wk in late adolescence (17–20 years of age). Earlier starters in higher representative teams accumulated slightly more hrs/wk in rugby-specific practice and play across their youth when compared to those who started later. Players engaged in a mean of two other sports across their youth and this reduced in late adolescence. In contrast, greater diversity in other sports in childhood compared to Cupples et al. (2018) along with similar youth engagement in rugby-specific play and practice was reported by Rothwell et al. (2017) in their interviews assessing practice experiences of professional rugby league players in Britain who had achieved either international or national standard. Further understanding of developmental activities of professional British rugby league players would not only supplement the current literature in expertise in rugby league (Till et al. 2010, 2017; Rothwell et al. 2017; Cupples et al. 2018), but would also provide more information for future talent identification and development systems within rugby league, particularly in the United Kingdom, where financial and geographical implications restrict teams from simply recruiting adult experts, so they must instead rely on ‘home-grown’ players within their squad.

The aim of the present study was to examine differences in the developmental activities of male, adult British rugby league players who were either professional, recreational, or who had played in the youth academies of professional clubs but did not become a professional player. Based on the contrasting literature surrounding sporting milestones (e.g., start age in the sport), as well as the type and amount of sport-specific and other sport activities (for reviews, see Güllich et al. 2020a, 2020b), we have forgone formulating respective a priori directed hypotheses.

Materials and methods

Participants

Eighty participants were initially approached, and of those 73-male rugby-league players with a mean chronological age of 25.80 ($sd = 4.85$) years volunteered to participate and was each assigned to a group based on current skill level. Participants were recruited and selected through convenience sampling from the research team’s network of contacts based on

previous links with the rugby-league clubs. At the time of data collection, no member of the research team held a coaching role at any of the clubs, nor had they worked directly with any of the participants throughout their development. Data was collected between the 2017–2019 seasons. The first group (Professional) comprised of 31 rugby-league players with a mean age of 25.97 ($sd = 4.45$) years from professional rugby-league clubs ($n = 2$) located in the North of England, currently competing in the Super League (highest tier). During their childhood they played rugby for various training academies of professional clubs ($n = 5$) and signed a professional contract at their respective club between 16 and 18 years of age (typically when a player signs their first professional contract). From the 31 players in the Professional group, 6 have represented their country at international level. The second group (ex-Academy) comprised of 18 males with a mean age of 23.60 ($sd = 1.88$) years who had played rugby for various training academies of professional clubs ($n = 4$), but by 18 years of age, had not been offered a contract by their respective clubs. These players were considered not to possess the ability required to progress to professional status in adulthood. Once they were released from the club, these participants played rugby-league at semi-professional (Championship and League 1; Tier 2 and 3/5) or amateur (National Conference League; Tier 4/5) standard ($n = 14$) or ceased participation altogether ($n = 4$). The third group (Recreational) comprised of 24 males with a mean age of 27.42 ($sd = 6.33$) years who had never played at youth academy level, yet currently play rugby-league for amateur/local community ($n = 10$) clubs (i.e., regional leagues; Tier 5 of 5) located in the North of England. All participants provided written informed consent. The study was designed in accordance with the Declaration of Helsinki and approved by Liverpool John Moores University ethics committee.

Questionnaire

The Participation History Questionnaire (PHQ) was used to elicit information relating to activities that players had engaged in during their development. The PHQ has been used in previous studies examining developmental pathways of soccer players (Ford and Williams 2012; Ford et al. 2012, 2020) and is based on Côté et al.'s (2005) recommendations. The reliability and validity of retrospective primary/main sport hours-per-week in the PHQ were shown in Ford et al. (2010), with a large interclass correlation coefficient (ICC) of 0.87 for a three-month test re-test and 0.76 for parent/player validity. Questionnaires that have used similar and/or identical questions as the PHQ have shown a large ICC of 0.86 for a three-month test re-test and 0.71 for parent/player validity of the yearly total practice hours (Haugaasen et al. 2014), as well as a high test re-test recall correlations for hours of practice ($r = 0.91$ – 0.95 ; Ward et al. 2007). This type of retrospective questionnaire method is regarded as one of the best available methodologies for collecting developmental activity data from professional athletes (Hopwood 2015). The questionnaire contained three sections. The first section was designed to elicit information on rugby league-specific milestones. These milestones included the age at which the participants first took part in rugby league (i.e., start age), and their start ages in supervised rugby league practice, rugby league competition, and

participation in the training academy of a professional club. The second section of the questionnaire was designed to elicit information on their engagement in rugby league activities. Altogether, four rugby league activities were listed: competition (i.e., organised competition usually between two teams supervised by adults/coaches); coach-led practice (i.e., organised group practice supervised by coaches, e.g., team practice); individual practice (i.e., practice alone supervised by themselves e.g., practicing kicking alone); play (i.e., games with rules supervised by yourself/peers, e.g., touch rugby league with friends/teammates). These activities were chosen based on previous research in which retrospective questionnaires were used (e.g., Ford et al. 2009) and to match the recommendations proposed by Côté et al. (2005). Participants were required to report the hours per week and months per year for each of the rugby league activities, as well as weeks when they were injured per year. Information was recorded each year from the current season back to the age group at which participants began playing rugby league. Prior to the start of each year, to aid recall the participants were required to report the team and coach they played for. The third section of the PHQ was designed to elicit information on engagement in other sport activities. It contained a list of sports (plus space to add sports) from which participants were required to indicate those in which they had participated in regularly for at least a total minimum period of 3 months. Previous studies using the PHQ have reported the amount and type of activities engaged in other sports (e.g., Ford et al. 2020), but due to having limited time with the participants (max = 60 min) we prioritised collecting primary sport data and thus, participants were only required to report the number of other sports. Participants were not required to include other sport activities engaged in during physical education classes at school, though those engaged in after school were included.

Procedure

One of the researchers who was familiar with the procedure visited the participants from each group to collect the data. To complete the questionnaire, participants from each group sat together in a quiet room. Verbal instructions were provided to participants regarding the purpose of the questionnaire. Participants were instructed how to complete the first section of the questionnaire before commencing the next section as a group when they were instructed how to do so. This procedure occurred for all three sections. Participants completed the questionnaire within 60 min limit.

Data analysis

For the milestone data, we calculated the mean years of age achieved for each group. For other sports engaged in, we calculated the mean total number of other sports for each group during childhood (6–12 years of age) and adolescence (13–18 years of age). For the rugby league-specific activity data, we calculated the hours accumulated in competition, coach-led practice, individual practice, and play during childhood (6–12 years of age), early (13–15 years of age) and late (16–18 years of age) adolescence for each group. An independent sample t-test was used to examine when professional and ex-academy players entered the training

academy of a professional club. One-way between group analysis of variance (ANOVA) was used to separately examine milestone data, other sports engaged in, and to separately examine rugby league-specific activity data for childhood, early, and late adolescence. The one-way ANOVA is considered a robust test against the normality assumption (Field 2017). Any violations of sphericity were corrected using Welch procedures. The effect sizes were calculated using partial eta squared (η_p^2) and Cohens d . Post-hoc tests were analysed using Tukey HSD and Games-Howell. The Alpha level required for significance for all tests was set at $p < .05$.

Results

Milestones

Table 1 contains the average age at which participants in each group reached rugby league-specific milestones. The one-way ANOVA revealed no significant differences for start age in rugby league [$F(2, 70) = 0.42, p = 0.66, \eta_p^2 = 0.01$], practice [$F(2, 70) = 0.24, p = 0.79, \eta_p^2 = 0.01$] and competition [$F(2, 70) = 0.25, p = 0.79, \eta_p^2 = 0.01$]. An independent t-test revealed no significant difference between the professional and ex-academy players entering youth academies of professional clubs [$t(47) = -0.79, p = 0.43, d = 0.23$]. The 73 participants from all groups started playing rugby league at a mean age of 7.38 ($sd = 2.40$) years. They began supervised training with a coach at the mean age of 7.49 ($sd = 2.37$) years and participated in competition at a mean age of 7.79 ($sd = 2.25$) years. The 49 participants in the professional and ex-academy groups first entered an elite training academy at the mean age of 14.21 ($sd = 1.36$) years.

Rugby league activities

Table 1 contains the hours accumulated in sport-specific activity between start age and 18 years for each group. One-way ANOVA revealed a significant difference between groups for total hours accumulated [$F(2, 40.56) = 27.94, p < 0.01, \eta_p^2 = 0.26$]. From start age to 18 years, the professional players accumulated significantly more hours in rugby league activities when compared to the ex-academy and recreational players ($p < 0.01$). The ex-academy players accumulated similar hours compared to the recreational ($p > 0.05$).

Figure 1a contains the hours accumulated in sport-specific activities during childhood (6–12 years of age). The one-way ANOVA revealed no group differences for competition [$F(2, 70) = 0.91, p = 0.40, \eta_p^2 = 0.03$] or individual practice [$F(2, 26) = 3.08, p = 0.06, \eta_p^2 = 0.17$], but the hours accumulated in coach-led practice during childhood significantly differed across groups [$F(2, 44.98) = 4.65, p = 0.02, \eta_p^2 = 0.08$]. A Games-Howell *post-hoc* test showed that the professional players

accumulated significantly greater hours of coach-led practice compared to the ex-academy players ($p = 0.03$). There were no differences between the professional and recreational ($p = 0.27$) players, or between ex-academy and recreational ($p = 0.10$) players. The ANOVA further revealed the hours accumulated in play during childhood significantly differed across groups [$F(2, 23.05) = 6.29, p = 0.01, \eta_p^2 = 0.19$]. A Games-Howell *post-hoc* test showed that the professional players accumulated significantly greater hours of rugby-specific play compared to the recreational ($p = 0.01$) and ex-academy players ($p = 0.01$). There were no differences between the ex-academy and recreational players ($p = 0.93$).

Figure 1b contains the hours accumulated in sport-specific activities during early adolescence (13–15 years of age). The one-way ANOVA revealed the hours accumulated in competition during childhood significantly differed across groups [$F(2, 71) = 4.58, p = 0.01, \eta_p^2 = 0.10$]. A Tukey *post-hoc* test showed that the ex-academy players accumulated significantly greater hours of competition compared to the recreational players ($p = 0.02$). There were no differences between the ex-academy and professional players ($p = 0.67$) or between professional and recreational players ($p = 0.06$). Although the ANOVA revealed no group differences for individual practice [$F(2, 33) = 1.99, p = 0.17, \eta_p^2 = 0.10$], the hours accumulated in coach-led practice during childhood significantly differed across groups [$F(2, 39.78) = 19.45, p < 0.01, \eta_p^2 = 0.22$]. A Games-Howell *post-hoc* test showed that the professional and ex-academy players accumulated significantly greater hours of practice compared to the recreational players ($p < 0.01$). There were no differences between the professional and ex-academy players ($p = 0.30$). The ANOVA further revealed the hours accumulated in play during early adolescence significantly differed across groups [$F(2, 28.75) = 4.69, p = 0.02, \eta_p^2 = 0.14$]. A Games-Howell *post-hoc* test showed that the professional players accumulated significantly greater hours of play compared to the ex-academy ($p = 0.03$) and recreational ($p = 0.01$) players. There were no differences between the ex-academy and recreational players ($p = 0.87$).

Figure 1c contains the hours accumulated in sport-specific activities during late adolescence (16–18 years of age). The one-way ANOVA revealed no group differences for competition [$F(2, 70) = 1.03, p = 0.36, \eta_p^2 = 0.03$], individual practice [$F(2, 50) = 0.44, p = 0.64, \eta_p^2 = 0.02$], or play [$F(2, 16.85) = 2.22, p = 0.14, \eta_p^2 = 0.14$], but hours accumulated in coach-led practice during late adolescence significantly differed across groups [$F(2, 37.83) = 88.43, p < 0.01, \eta_p^2 = 0.39$]. A Games-Howell *post-hoc* test showed that the professional and ex-academy players accumulated significantly greater hours of practice compared to the recreational players ($p < 0.01$). The professional players also

Table 1. Mean (sd) milestones in years of age achieved by each group (* = $p < 0.05$).

	Start age in Rugby	Start age in supervised practice	Start age in competition	Start age in professional academies	Total hours accumulated by 18 years
Recreational	7.50 (2.84)	7.54 (2.83)	7.92 (2.81)		1614.15 (628.18)
Ex-Academy	7.74 (2.37)	7.78 (2.29)	8.00 (2.11)	14.00 (1.37)	2852.52 (868.75)
Professional	7.10 (2.06)	7.29 (2.07)	7.58 (1.86)	14.32 (1.38)	4689.69 (2652.90) *

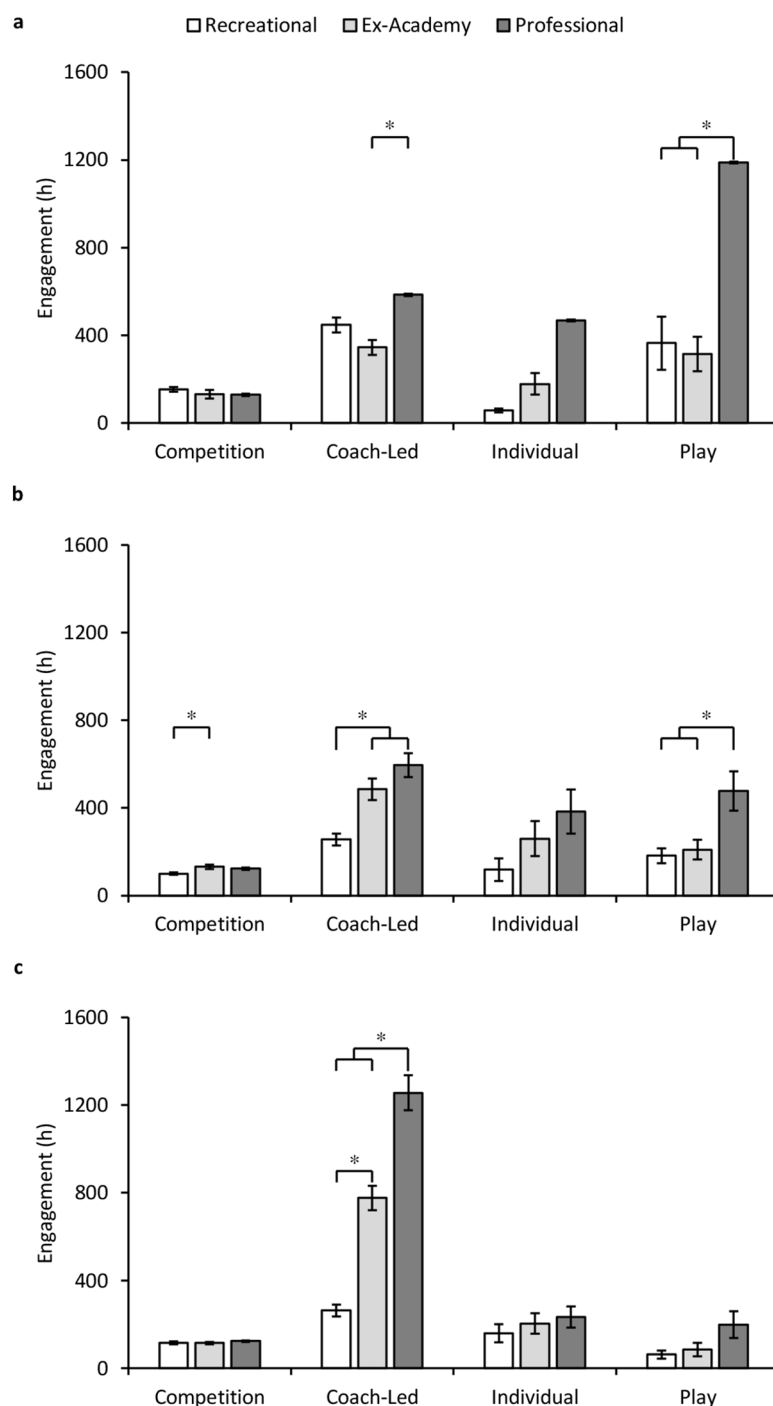


Figure 1. Hours accumulated (error bars represent standard error of the mean) during (a) childhood (6–12 years of age), (b) early adolescence (13–15 years of age), and (c) late adolescence (16–18 years of age) in competition, coach-led practice, individual practice and play for the Recreational (white bars), Ex-Academy (light-grey bars) and Professional (dark-grey bars) players (* = $p < 0.05$).

accumulated significantly greater hours of practice compared to the ex-academy players ($p < 0.01$).

Engagement in other sports

Table 2 contains the total number of other sports engaged in during childhood and adolescence for players in each

group. The one-way ANOVA revealed no significant effects for the number of sports engaged in during childhood [$F(2, 47) = 0.41, p = 0.67, \eta_p^2 = 0.03$] or adolescence [$F(2, 25.24) = 1.12, p = 0.34, \eta_p^2 = 0.03$]. From all 73 participants, 50 engaged in a mean of 2.46 ($sd = 1.90$) other sports sometime during childhood. Of the 50 players who engaged in other sports during childhood, 7 of them did

Table 2. Mean (*sd*) number of other sports engaged in and the number of players who engaged in them during childhood (6–12 years of age) and adolescence (13–18 years of age) by each group (* = $p < 0.05$).

	Childhood		Adolescence	
	Number of other sports	Number of players	Number of other sports	Number of players
Recreational	1.91 (1.04)	9	2.44 (1.34)	8
Ex-Academy	2.54 (1.71)	13	2.33 (1.37)	13
Professional	2.92 (2.95)	14	3.12 (3.25)	14

not engage in other sports during adolescence. Moreover, 12 players began engaging in other sports for the first time during adolescence. During adolescence, 55 of the players engaged in a mean of 2.63 ($sd = 1.99$) other sports.

Discussion

In present study, we examined the developmental activities of male, adult British rugby league players who were either professional, recreational, or who had played in the youth academies of professional clubs but did not become a professional player as they were considered to not possess the necessary skills. Our findings for professional players were remarkably alike to that reported by Cupples et al. (2018). Professional players recorded similar milestones compared to ex-academy and recreational players. All players started rugby league during early childhood at 7 years of age, similar to Rugby players in Australia (Cupples et al. 2018), later than reported for British soccer players (5 years of age, Roca et al. 2012; Ford and Williams 2012) and earlier to those observed in international hockey players (Drake and Breslin 2018). Both professional and ex-academy players first entered training academies of professional clubs at 14 years of age. This was expected, as currently talented youth rugby league players in Britain cannot be selected to enter elite (i.e., category one) club training academies until they are 14 years of age (Rugby Football League 2019), which is similar to Australia (15 years of age; Cupples et al. 2018). It should be noted that minimum age for entering elite training academies has varied over the years, and therefore, some players may have entered the elite training academy at an earlier age. In the current study, eight Professional and six Ex-Academy entered before 14 years of age.

Despite the similar milestones, the childhood sport-specific activities of professional players differed to the other groups. Professional players engaged in three times ($\approx 1,200$ h) as many hours in rugby-specific play between 6 and 12 years of age when compared to the ex-academy and recreational players (see Figure 1a). This higher amount of hours in peer-led play engaged in by professional players (1,188 h across 7 years/3.4 h/wk across 50 wk years) was similar to Australian rugby league players (3–5 h/wk) at a similar age (Cupples et al. 2018) and accumulated hours of international female soccer players (~ 900 h; Ford et al. 2020), but greater than national Canadian female soccer players (~ 415 h; Hendry et al. 2019b). Côté et al. (2007); (2012) suggested that engagement in high levels of peer-led play across development would facilitate future intrinsic motivation. However, empirical evidence to support this suggestion is currently lacking, and instead there are dissenting

findings (e.g., Thomas and Güllich 2019; Hendry et al. 2019a). Still, the data demonstrates the prevalence of sport-specific play alongside practice in the childhood of professional athletes.

In early adolescence professional and ex-academy players engaged ≈ 300 more hours in coach-led practice when compared to recreational players (see Figure 1b). In Rugby league in Australia, it has previously been shown that on average the engagement in rugby specific practice increased from 2 to 3 h/wk in childhood 10–15 h/wk in late adolescence when players were entered into training academies (Cupples et al. 2018). Consistent with Australia, professional players in Britain increased their engagement in coach-led practice from 1.7 h/wk in childhood to 9.8 h/wk in late adolescence, compared to 1.3 h/wk increase in recreational players. In contrast, on average professional players engagement in peer-led play decreased from 3.4 h/wk to 1.3 h/wk in late adolescence (see Figure 1c). Furthermore, by 18 years of age, professional players had accumulated 4,690 h in all rugby league activities. Though lower when compared to international female soccer players (Ford et al. 2020), it is higher compared to other team sport athletes including Olympic champion male field hockey players (Güllich 2014b), as well as world-class male and female soccer players (Hornig et al. 2016; Güllich 2019). The differences in accumulated hours in rugby league activities, specifically the hours in coach-led practice are likely due to changes in the structures of the pathway of rugby league in Great Britain. For example, currently players can only enter an elite training academy at 14 years of age (Rugby Football League 2019), yet this legislation has been reformed numerous times over the years, resulting in players having permission to enter the same elite training academy environments at different ages. Furthermore, typically rugby league players can sign a professional contract between 16 and 18 years of age (again legislation has changed over time). Professional players in current study signed their first professional contract at a mean age of 16.40 ($sd = 0.89$) years. These players are likely to have been exposed to more hours in coach-led practice during this time as part of a senior team environment. This is supported by professional players increased their engagement coach-led practice from 5.9 h/wk before signing (15–16 years of age) to 11.1 h/wk following signing (17–18 years of age). Data from engagement in other sports indicated that professional rugby league players had some diversification into other sports. The players in the present study engaged in an average of two other sports during childhood (2.46) and adolescence (2.58) which again is similar to rugby league players in Australia (2; Cupples et al. 2018), but slightly lower than in soccer (4; Ford et al. 2012; Ford and Williams 2012) and field hockey players (4; Drake and Breslin 2018). Early studies that have been used as evidence to promote sampling of multiple sports during childhood (i.e., diversification) have shown that team sport athletes in Canada engage in six other sports (Soberlak and Côté 2003), whereas in Australia they engage in eight other sports (Baker et al. 2003). Engagement in other sports has been shown to be beneficial for expert performance attainment (Güllich 2014a, 2017) with engagement in other sport coach-led practice correlating to attainment (Güllich et al. 2020a, 2020b). In the present study, the relatively low number of other sports engaged in may be

due to the differences between studies in methods employed to examine engagement in other sport activity (Cupples et al. 2018; Güllich 2019; Ford et al. 2020).

Other studies, including those using the PHQ, have reported the *amount* and type of activities engaged in other sports (e.g., Hendry et al. 2019b; Ford et al. 2020), but in the present study we only collected data on the number of other sports engaged in across development, similar to Cupples et al. (2018). Previous studies examining the developmental activities have identified that engagement in the amount and type of other-sport activity can differentiate performance levels in their main sport (Güllich et al. 2020a, 2020b). Although the current study only reported a small number of other sports engaged in (~2 other sports), future studies of this kind should report the hours engaged in these other sports and distinguish the amounts of engagement in coach-led practice and in peer-led play in those sports. Second, we examined the engagement in macro-activities of rugby league, and we did not study the microstructure (i.e., game-based, drill-based, fitness) of these activities or the effects on skill acquisition (Ford, Yates, & Williams 2010; Güllich 2019). Third, retrospective recall data may also be limited by memory error and inference when participants are required to recall activities from childhood. A causal link between activities engaged in and level of attainment should not be inferred from retrospective data of this nature. Longitudinal studies of how all the activities differentially affect skill acquisition during childhood is still required. Future research should seek to examine whether and how engagement in specific types of practice activities leads to obtaining the necessary skills required for expert performance in rugby league. In doing so, the findings could be used to inform future practice of talent development systems within rugby league clubs in Britain, increasing the possibility of developing future elite rugby league players.

To summarise, the developmental activities of professional male British rugby league players consisted of early engagement in rugby league activities, with relatively high amounts of rugby-specific play during childhood and early adolescence compared to players who were deemed not to possess the necessary skills to become professional. The hours accumulated in rugby-specific practice increased significantly across development into late adolescence, with greater amounts of this activity found for professional players compared to ex-Academy across development. Professional players engaged in relatively low number of other sports across their development and did not differ when compared to the ex-academy and recreational players.

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Data availability

The data that support the findings of this study are available on request from the corresponding author (MA). The data are not publicly available due to restrictions (e.g., their containing information that could compromise the privacy of research participants).

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