The developmental and professional activities of female international soccer players from five high-performing nations

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The developmental pathways and professional activities of female international soccer players from five high-performing nations
Abstract

We study the developmental and professional activities engaged in by 86 female adult soccer players from the senior national teams of Australia, Canada, England, Sweden, and the United States of America. Players completed the Participation History Questionnaire (PHQ) to elicit the amount and type of activities engaged in across their developmental and professional years, including milestones, soccer-specific activity and engagement in other sport activity. Commonalities in the developmental activities between the 86 players were an early start age in the sport, early engagement in soccer activity, with the majority (78%) showing varying levels of early diversification in other sports ($M = 3.2$ other sports), which for mean hours accumulated in childhood was half that for soccer activity. The amount of coach-led soccer practice increased for all players across their development culminating in an average of 15-16 hr/wk across a 40-week season in early adulthood. In contrast, the amount of engagement in other sports and soccer peer-led play varied between players, but decreased across adolescence to negligible amounts in late adolescence. Findings support the early engagement hypothesis, the early diversification pathway, and are commensurate with the deliberate practice framework.

**Keywords:** Deliberate practice; talent development; motor behaviour; skill acquisition.
Introduction

Professional athletes excite us with their outstanding performances and achievements. The activities they participate in during development and across their careers contribute to the attainment of expertise. In contrast to the fairly substantive literature based on male expert athletes, and particularly male soccer players (e.g., Ford et al., 2012; Hendry & Hodges, 2018; Hornig, Aust, & Güllich, 2016) very few researchers have studied the developmental activities of female expert athletes. In this study, we address this shortcoming in the literature by assessing the developmental and professional activities engaged in by adult, international-level, female soccer players.

Deliberate practice theory (Ericsson, 1996; 1998; 2003; 2006; 2007; 2013; Ericsson, Krampe, & Tesch-Römer, 1993; Ericsson & Towne, 2010; Ericsson & Pool, 2016) has been hugely influential in shaping ideas about the development of expert performance. The central parts of deliberate practice theory are the characteristics of deliberate practice and the monotonic benefits assumption. The characteristics of deliberate practice are that it is highly relevant to improving current performance, effortful, and relatively low in inherent enjoyment. The monotonic benefit assumption is that time accumulated in deliberate practice is monotonically related to performance, in that increases in the former lead directly to increases in the latter. Therefore, key claims in the framework first outlined by Ericsson et al. (1993) are that “...the level of performance an individual attains is directly related to the amount of deliberate practice accumulated” (p.370) and that “...individuals who start early and practice at higher levels will have a higher level of performance throughout development than those who start later” (p.392). In sport, these claims have led to the belief that the start of engagement in deliberate practice should
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 occur early in childhood and that children should specialize in a sport so as to maximize time spent in this activity. The American Orthopaedic Society for Sports Medicine (AOSSM) recently published a Consensus Statement (LaPrade et al., 2016) in which they defined three criteria for early sports specialization. First, it involves engagement in intensive practice/training and/or competition for 8 months per year or greater, with low amounts of free play. Second, it involves engagement in a single sport with no participation in other sports. Third, it involves children aged 12 years or younger.

Early sports specialization has been associated with negative consequences for those involved, including increased incidence of overuse injuries, social isolation, burnout and dropout during adolescence, as well as reduced success in sports in adulthood (for reviews, see Baker, Cobley, & Fraser-Thomas, 2009; Bergeron et al., 2016; DiFiori et al., 2014; Jayanthi, Pinkham, Dugas, Patrick, & La Bella, 2012; Mostafavifar, Best, & Myer, 2013; Rees et al, 2016; Wojtys, 2013). An alternative to early sports specialization is early sports diversification or sampling. The early sports diversification or sampling pathway involves participation in various sports and engagement in deliberate play with no engagement in deliberate practice during childhood (Côté, Lidor, & Hackfort, 2007). As a consequence, specialisation in a single sport is delayed until adolescence. Early sports diversification or sampling is postulated to lead to several positive consequences for those involved, including enhancing intrinsic motivation and other psychosocial variables, reducing overuse injuries, attaining expertise in adulthood, and longer sports careers (for reviews, see Côté & Erickson, 2015; Côté, Horton, MacDonald, & Wilkes, 2009; Côté et al., 2007). Early sports specialisation and diversification are differentiated as pathways to
expert performance with their associated consequences in the Developmental Model of Sport Participation (Côté, Baker, & Abernethy, 2007).

Deliberate practice theory (e.g., Ericsson et al., 1993) and the specialisation/diversification pathways have been assessed using retrospective recall methods in which the amount of hours spent in developmental activities by expert performers since starting in the domain are recorded via interviews and questionnaires. Multiple researchers have used this method with athletes from a variety of sports and countries (for reviews, see Baker & Young 2014; Güllich & Emrich, 2014). One of the strongest current forms of evidence is from cross-sectional studies involving adult athletes performing at the highest level in their sport separated into groups who are close together on the expertise continuum, such as “world class” versus “national” level adult athletes, albeit the terms used to describe athletes often differs between studies (Berry, Abernethy, & Côté, 2008; Carlson, 1988; Hornig et al., 2016; Law, Côté, & Ericsson, 2007; Güllich, 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich & Emrich, 2014; Moesch, Elbe, Hauge, & Wikman, 2011; Van Rossum, 2000; Zibung & Conzelmann, 2013). However, differences in activities between groups close together on the expertise continuum do not necessarily mean those differences caused the groupings. No studies exist involving longitudinal measurement of how all the activities differentially affected skill acquisition during development. Moreover, studies involving samples of adolescent athletes are limited because many of those athletes do not become adult athletes performing at the highest level in their sport, with those athletes cofounding the data when assessing the contribution of activities to the development of expert performance. Moreover, “expert-novice” comparisons usually reveal the obvious finding that “experts” have accumulated
significantly more sport-specific practice hours compared to “novices” (for a review, see Baker & Young, 2014).

Both early diversification and early specialisation have been shown to characterise the developmental activities of professional adult athletes. Early specialisation characterised the developmental activities of Olympic and international standard adult female rhythmic gymnasts (Law et al., 2007). The gymnasts engaged in a sport that requires peak performance in adolescence, so early specialization may have been necessary. Early specialisation characterised the developmental activities of some of the Swiss national team male soccer players in Zibung and Conzelmann (2013), some of the German national team female soccer players in Güllich (2019; 29% of group), and some of the Olympic and/or World Champion medalist German athletes in Güllich (2014; 25% of group). However, in these three studies the developmental activities of the majority of participants demonstrated early diversification. Moreover, elsewhere, aspects of early diversification characterised the developmental activities of the most-successful adult athletes performing at the highest level in their sport (Berry et al., 2008; Carlson, 1988; Hornig et al., 2016; Güllich, 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich & Emrich, 2014; Moesch et al., 2011; Van Rossum, 2000).

The early engagement hypothesis (Ford, Ward, Hodges, & Williams, 2009) was created because specialisation/diversification pathways did not adequately explain some of the complexity in developmental activities. In this case, some athletes begin engagement during childhood in the sport they later achieve expertise. In addition, some of those athletes concurrently engage in elements of early diversification, such as peer-led play, which means their developmental activities do not match the early specialisation
pathway. However, some athletes engage in elements of early diversification, such as multiple sports, but *do not* engage during childhood in the sport in which they achieve expertise. The early engagement hypothesis was created to differentiate between non-specialising athletes who do or do not engage during childhood in the sport in which they achieve expertise. For example, female and male German national team soccer players started engaging in the sport in childhood (Güllich, 2019; Hornig et al., 2016). Moreover, early engagement is hypothesised to be more likely to occur in sports that are culturally popular, have a high number of participants, are technically demanding, and have a well-developed child sport system (Ford & Williams, 2017).

Another contextual factor that may influence the amount and type of developmental activities is gender (Ford & Williams, 2017). Researchers have shown that females in the general population engage in less physical activity during childhood and adolescence compared to males (e.g., Sherar, Esliger, Baxter-Jones, & Tremblay, 2007; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003). These consistent gender-based differences in youth physical activity in the general population suggest that the developmental activities and pathways of female athletes may differ to those reported for their male counterparts.

Male and female athletes have been directly compared in a study of national team sport athletes in Australia (Baker, Côté, & Abernethy, 2003). Females had accumulated fewer sport-specific hours during their development, but had greater diversity in sport participation, when compared to their male counterparts. However, in another study of male and female elite Canadian triathletes, time spent in the primary sport during development did not differentiate genders (Hodges, Kerr, Starkes, Weir, & Nananidou, 2004). Two other studies have assessed the developmental activities of female athletes.
First, female German national team soccer players demonstrated greater engagement across childhood and adolescence in peer-led play in soccer and coach-led other sports, with lower engagement in coach-led soccer practice, later milestones and later specialisation when compared to league players (Güllich, 2019). Second, the female Olympic rhythmic gymnasts studied by Law et al. (2007) accumulated a very high amount of sport-specific practice hours and had low amounts of diversity in other sports in their youth. The mixed results from studies investigating the developmental activities of female athletes suggest further study is required.

In the current paper, we study the developmental and professional activities of female adult national team soccer players from around the world. Players were selected from countries playing at the highest level of the sport (international and/or professional), representing the senior national teams of Australia, Canada, England, Sweden and United States of America. Participants completed a questionnaire assessing the number of hours spent in developmental and professional activities since starting in the sport. Their developmental activities during childhood should follow the early diversification pathway as per the most-successful adult athletes performing at the highest level in their sport (Berry et al., 2008; Carlson, 1988; Hornig et al., 2016; Güllich, 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich & Emrich, 2014; Moesch et al., 2011; Van Rossum, 2000).

However, the developmental activities of a proportion of players (~25%) were expected to follow the early specialisation pathway as reported in some previous studies (Güllich, 2014; 2019; Zibung & Conzelmann, 2013), which would be demonstrated by a significant accumulation of hours in soccer during childhood with no or little engagement in other sports. Early engagement in soccer was expected for all players similar to German
national team soccer players (Güllich, 2019; Hornig et al., 2016). In addition, the female soccer players were expected to have engaged in increasing amounts of practice in soccer across adolescence, with hours in soccer-specific play and other sports reducing across adolescence, as per previously outlined pathways (Côté, Abernethy et al., 2007). We hypothesized that from late adolescence their activities would involve high volumes of soccer practice commensurate with the deliberate practice framework (e.g., Ericsson et al., 1993).

Method

Participants

Participants were 86 adult, female, international soccer players in the squads of Australia, Canada, England, Sweden, and the United States of America (n = 16 -18 players from each country). Their mean age at the time of data collection was 25.7 yr (SD = 4.1 yr). All the teams were ranked in the top 10 of the Federation Internationale de Football Association (FIFA)/Coca-Cola World Ranking. Players were part of the national squads for their respective countries at the time of data collection and had played at least one official match for their national team (median = 28 appearances, IQ1 = 8, IQ3 = 76, with 11 players over 100 appearances). Informed consent was obtained and the research was conducted according to the ethical guidelines of the lead author’s institution [name deleted to maintain the integrity of review process].

Questionnaire

The Participation History Questionnaire (PHQ) was used to elicit information relating to the activities that players had engaged in across their developmental and professional years. Indices related to the reliability and validity of the PHQ have
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previously been reported (e.g., Ford, Low, McRobert & Williams, 2010) and its use is widespread (e.g., Ford et al., 2010; 2012; Ford & Williams, 2012; Winn, Ford, McNarry, Lewis, & Stratton, 2017). The first of the three sections of the questionnaire elicited information on soccer-specific milestones. These included the age at which participants first started playing in soccer of any type, supervised soccer practice, entered a ‘talent development’ training programme (i.e., academy), appeared at youth international level, senior level, senior international level, and in an Olympic Games. Players were required to list their senior honours and the years they occurred. The second section solicited information on engagement in four types of soccer activities: match-play; coach-led practice; individual practice; and non-coach-led play (Côté, Ericsson, & Law, 2005; Ward, Hodges, Starkes, & Williams, 2007). Match-play was defined as organized competition in a group engaged in with the intention of winning and supervised by adult(s) (e.g., league games). Coach-led practice was defined as organized group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s) (e.g., practice with team). Non-coach-led individual practice was defined as practice alone engaged in with the intention of performance improvement. This latter category was included because researchers have studied individual practice hours to test ideas relating to deliberate practice theory (Ericsson et al., 1993). Non-coach-led play was defined as play-type games with rules supervised by the player or their peers and engaged in with the intention of fun and enjoyment (e.g., game of soccer in park with friends). The hours/week and months/year in each of the soccer activities, including the number of weeks when players were injured/year, were recorded for a year. Data was recorded for
every other year from the current season retrospectively to the under-6 year (U6) age group category.

The third section of the PHQ elicited information on engagement in other sport activities. It contained a list of sports, from which, participants were asked to indicate those sports in which they had participated regularly for at least three months in total (e.g., once a week for one month in each of three years). They were not required to include sport activities engaged in during physical education classes at school, although those engaged in after school were included.

**Procedures**

To complete the questionnaire, participants from each squad sat together in small groups in a quiet room. Verbal instructions were provided regarding the purpose of the questionnaire. Participants were instructed on how to complete each section of the questionnaire before commencing that section. At the start of the second section, players were required to specify the team and coach that they played for in each year of their participation to aid memory recall of the hours in the soccer activities. Participants completed the questionnaire in about one hour.

**Data analyses**

All dependent variables are reported combined for the 86 participants. We did not make between-country comparisons, as there was no rationale to expect significant differences between countries (e.g., Ford et al., 2012).

**Milestones.** Milestone data and honours were reported as descriptive statistics.

**Activity data.** The hours recorded in soccer activity was recorded for every other year between the current season and start age, so linear interpolation was used for the
missing years (i.e., average of the year preceding and succeeding). These hours were split
into childhood (6-12 yr), adolescence (13-18 yr), and early adulthood (18-25 yr) stages for
practice, play and competition. Soccer-specific practice hours were the sum of individual
and team practice, although the number of individual soccer practice hours was relatively
low (e.g., in childhood, 62/86 participants reported and accumulated mean 682 hrs, $SD =
623$). The accumulated soccer hours within each of the three age stages as a function of
soccer activity type were used. The number of other sports and hours accumulated in
those other sports were calculated separately for the childhood, adolescence and
adulthood stages.

**Childhood activities.** For the soccer activity data during childhood, we conducted
a one-way ANOVA between activity types (practice, play, competition) with Bonferroni
post hoc comparisons. Number of other sports and hours accumulated in those other
sports during childhood were reported as descriptive statistics.

**Adolescent activities.** To test whether amounts of practice in soccer increased
across adolescence, but soccer-play and other sports activity decreased, the activity data
were divided into early (13-15 yrs) and late (16-18 yrs) adolescent stages. Hours
accumulated in soccer practice and play activities, as well as number of other sports and
hours accumulated in other sports, were analysed separately using dependent t-tests
comparing between age stages (early, late). Bonferroni correction to the alpha level
resulted in a significance level of $p < .0125$ for these four t-tests. Effect size measures
were calculated using partial eta squared ($\eta_p^2$).
**Adult activities.** Activity data for early adulthood (19-25 yrs) were calculated and are reported as descriptive statistics for any players that had reached 25 years of age. Players younger than 25 years of age were excluded from the adult data.

**Results**

**Milestones and honours**

Table 1 contains the mean age at which players reached soccer-specific milestones. The 86 players started in soccer at a mean age of 5.4 yr ($SD = 1.4$), with every player starting participation in childhood. Players began supervised training at $M = 6.6$ yr ($SD = 2.2$) and in a league a year later ($SD = 2.6$). Of the 78/86 players that reported attending a youth training academy, this occurred at $M = 13.6$ yr ($SD = 3.3$). The first engagement in non-soccer training activities for soccer (such as weights) was at $M = 14.2$ yr ($SD = 2.5$). For 78/86 players who reported playing youth international soccer, their first appearance was at $M = 15.4$ yr ($SD = 1.6$ yr). The 86 players started in senior soccer at $M = 17.1$ yr ($SD = 2.6$). Players went on to achieve several honours in senior soccer and all achieved at least one appearance for their senior national team ($median = 28$ appearances, $IQ_1 = 8$, $IQ_3 = 76$, with 11 players over 100 appearances) at the time of data collection (2012/13). They first played for their national team at $M = 18.9$ yr ($SD = 3.2$) and 51/86 players first played at an Olympic Games at $M = 24.0$ yr ($SD = 4.8$). All players represented the senior team of a professional club. Honours included at the time of data collection included at least one Olympic Games medal for 29 players and World Cup winners or runner-up medals for 24 players, with 39 players winning national championships with their clubs. Many of the players have won more of these honours for both club and country in the intervening time period since data collection.
During childhood (6-12 yr), players accumulated an average of 2,519 hr \((SD = 1,861)\) in all soccer-specific activities, which equals an average of 7.2 hr/wk over each of seven, 50-week years during this period. Altogether, 80/86 players engaged in other sports during childhood. They engaged in \(M = 3.2\) sports \((SD = 1.9)\) and accumulated \(M = 1,040\) hr \((SD = 908)\) across this period, equating to an average of 3.0 hr/wk. Start age in other sports varied across childhood \((median = 9\ yr; \ IQ1 = 7; \ IQ3 = 12\ yr)\). It should be noted that there was variation in the data for hours accumulated during childhood. Altogether, 12/86 players \((14\%)\) accumulated more hours during childhood in other sports compared to soccer, whereas only 2/86 did so in adolescence. There were three other players whose hours accumulated in other sports during childhood were 300 hrs or less below those in soccer. For these 15/86 players \((17\%)\) of players, their mean number of other sports was 3.8 sports \((SD = 1.4)\). In contrast, 19/86 players \((22\%)\) accumulated less than 300 hours in other sports during childhood, with 6 of those players not engaging in other sports during this period \((7\%)\). The mean accumulated hours in soccer activity during childhood for these 19 players was 1,840 hrs \((SD = 1,032)\).

Figure 1 shows the hours accumulated in the three soccer activities during childhood. There was a significant difference in hours accumulated between the three soccer activities, \(F_{2,164} = 18.48, p < .01, \eta^2_p = .18\). Post-hoc tests showed that hours in competition \((M = 361\ hrs, SD = 383\ hr)\) were lower \((p’s < .01)\) compared with practice \((M = 1,337, SD = 1,087\ hr)\), and play \((M = 911, SD = 1,393\ hr)\), but there was no difference between practice and play \((p = .11)\). However, 20/86 players \((23\%)\) did not engage in play during childhood \((values = 0\ hrs)\). The mean for the 66 players who did was 1,146 hrs.
Variation was noted in these data for soccer activities and pathways. Soccer activity during childhood occurred more so in coach-led settings compared to peer-led play, but 16 players (19%) accumulated more hours during childhood in soccer-specific play compared to practice, whereas only 4 did so in adolescence (5%). When assessing childhood sports activity data as a whole and, specifically, players who specialised early, there were 19/86 players (22%) who engaged solely in soccer activity (when using less than 300 hrs accumulated in other sports during childhood to categorise).

Adolescence

Soccer activities. Figure 2 shows the hours accumulated in the three soccer activities during adolescence. Players accumulated $M = 3,489$ hrs (11.6 hr/wk across six 50-week years; $SD = 1,836$) in soccer activities across this period. Hours accumulated in soccer practice were greater in late ($M = 1,303$ hrs across 3 years / 8.7 hr/wk across 50-wk years, $SD = 638$) compared to early adolescence ($M = 1,002$ hrs across 3 years / 6.7 hr/wk across 50-wk years, $SD = 648$), $t_{85} = 6.86$, $p < .0125$. Hours accumulated in soccer play were lower in late ($M = 219$ hrs, $SD = 514$) compared to early adolescence ($M = 377$ hrs, $SD = 750$), $t_{85} = 4.45$, $p < .0125$. However, 28 and 32 players did not engage in soccer play during early and late adolescence, respectively. The actual mean for the 58 players who did engage in play during early adolescence was 560 hrs (3.7 hr/wk, $SD = 857$) and for the 54 players in late adolescence, $M = 350$ hrs (2.3 hr/wk, $SD = 615$). Hours accumulated during adolescence in soccer competition were 587 hrs (2.0 hr/wk across six 50-wk years, $SD = 367$).
Up to the age of 18 yr, which is the mean age that the 86 players first represented their national team, they accumulated an average of 6,007 hr ($SD = 2,813$) in all soccer activities (sum of practice, play and competition).

**Other sports.** Altogether, 80 players engaged in other sports in early adolescence dropping to 54 in late adolescence. Based on repeated measures comparisons of $n = 54$, the number of other sports was greater in early ($M = 3$ other sports, $SD = 2$) compared to late adolescence ($M = 2$ other sports, $SD = 2$), $t_{53} = 5.92, p < .0125$. Hours accumulated in other sports during early adolescence ($M = 697$ hrs across 3 years / 4.6 hr/wk across 50 wk/yr, $SD = 489$) were greater when compared to late ($M = 485$ hrs across 3 years / 3.2 hr/wk across 50 wk/ys, $SD = 520$), $t_{50} = 5.01, p < .0125$. Table 3 shows the type of sports that players participated in across their youth. Players engaged in 41 different additional sports, with basketball, swimming, athletics and cross-country running being the most common. Players ended participation in other sports at various ages across their youth, but mainly in adolescence ($median = 14$ yr; $IQ1 = 12$; $IQ3 = 18$ yr). Age of specialisation was $M = 16$ years ($SD = 2$) when using a criterion of within participant other sport end ages up to 18 years of age.

**Adulthood**

During early adulthood, between 19-25 yrs, the 46 players who had reached 25 years of age accumulated an average of 4,385 hr ($SD = 1914$) in soccer-specific coach-led practice activities, which equates to 15-16 hr/wk across a 40-week season or 12.5 hrs over 50-weeks, mainly in coach-led practice, as well as equating to playing one match/wk over a 40-week season. A total of 19 players engaged in $M =1.4$ ($SD = 0.8$) other sports between 19-25 yr.
Discussion

We evaluated the developmental and professional activities of female adult national team soccer players. Our aim was to determine the activity pathways of these players in relation to existing developmental pathways and previous data from male players. Given early diversification characterises the developmental activities of the most-successful adult athletes performing at the highest level in their sport (Berry et al., 2008; Carlson, 1988; Hornig et al., 2016; Güllich, 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich & Emrich, 2014; Moesch et al., 2011; Van Rossum, 2000), we expected to find the same in our sample. In addition, childhood engagement in soccer was expected for all players similar to German national team soccer players (Güllich, 2019; Hornig et al., 2016).

However, early specialisation was expected for around a quarter of all players similar to previous studies with soccer players (Güllich, 2019; Zibung & Conzelmann, 2013). We anticipated increasing amounts of practice hours from early adolescence onwards.

All players engaged from early childhood in soccer, and on average they accumulated over twice as many hours in soccer by 12 years of age when compared to other sports. However, there was variation from the average in that 17% of players accumulated more or relatively equal hours in other sports when compared to soccer, and, thus, could be considered to have diversified early. Moreover, another 22% of players accumulated few or no hours in other sports and, thus, could be considered to have specialised early, albeit 17% engaged in soccer-specific play during this period. As expected, hours in coach-led practice and competition in soccer increased across development, leading to significant increases between early and late adolescence, as well
as between adolescence and adulthood. Hours accumulated in other sports, soccer-specific play, and number of other sports decreased in the same manner.

The start age in soccer for all players was in early childhood (~ 5 yr), similar to start ages for elite, male players (Ford et al., 2009; 2012; Hendry, Crocker & Hodges, 2014; Hendry & Hodges, 2018; Hornig et al., 2016; Ward et al., 2007) and German female national team players (Gülich, 2019). During childhood, the players averaged 7 hrs/wk of soccer activity, again similar to previous research with elite, males (Ford et al., 2012; Hornig et al., 2016; Ward et al., 2007) and German female national team players (Gülich, 2019). Their start age in a youth training academy occurred in early adolescence ($M = 13.6$ yr) slightly later compared to male players (e.g., 12 yrs, Ford et al., 2012). This suggests that the early engagement in soccer activity mainly occurred at a recreational level and that the academy system for females recruits later compared to males. In addition, during childhood, the players engaged in an average of three other sports during childhood for around 3 hrs per week, supporting other research showing early diversification with early engagement (Berry et al., 2008; Carlson, 1988; Hornig et al., 2016; Gülich; 2019; Gülich et al., 2019; Moesch et al., 2011).

As expected, across adolescence, players increased hours in coach-led, soccer practice and decreased hours in soccer play and other sports, as well as having a median end age in other sports of 14 yrs, supporting data from elite, male (e.g., Ford et al., 2012; Hornig et al., 2016; Ward et al., 2007) and female players (Gülich, 2019). This pattern of results would be predicted based on deliberate practice theory (Ericsson et al., 1993) and both pathways outlined in the DMSP (Côté, Abernethy et al., 2007). It is similar to other studies of expert athletes (Berry et al., 2008; Carlson, 1988; Gülich, 2016; Hornig et al.,
2016). By 18 year of age, mean hours accumulated in all soccer activity were 6,007 hrs ($SD = 2,813$), which is lower when compared to German male national team players (Hornig et al., 2016), but is similar to German female national team players (Güllich, 2017) and their male Olympic Champion field hockey team (Güllich, 2014).

While there were notable commonalities between players, including an early childhood start in soccer, engagement in coach-led soccer activities during childhood, and the volume of practice increasing across development, variation was noted. A proportion of players (22%) did not engage in other sports or accumulated a low amount of hours in other sports during childhood, suggesting greater early specialisation in this sub-group, albeit they did not accumulate more hours in soccer activity during childhood than the sample average and 17 of those players concurrently engaged in soccer-specific play. The proportion of players who could be considered to have specialised early (22%) was similar to that found for German athletes (Güllich, 2014; 2019). Another proportion of players (17%) accumulated more or relatively equal hours in $M = 3.8$ other sports during childhood, suggesting greater early diversification in this sub-group when compared to the sample average. However, this is less diversification when compared to the British athlete super-elite group in Güllich et al. (2019), but is slightly greater compared to the German Olympic Champion field hockey team (Güllich, 2014).

One explanation for variation in hours accumulated in activities between expert performers during their development is that differences exist in the “quality” of those activities, with various activities contributing to a greater or lesser degree to skill acquisition (for a review, see Ford, Coughlan, Hodges, & Williams, 2015). A limitation of the current study is that we only examined engagement in macro-activities (practice, play,
competition). We did not study the microstructure of these activities, which would likely provide richer information about the effects of those activities (for a review, see Hendry, Ford, Williams, & Hodges, 2015). Another limitation of this study is that no measure of player performance or outfield position was included, so the observed variation could be attributable to player skill and position. Although this study is informative in helping describe developmental pathways that have preceded success in female soccer, it is important to remember that studies based on practice history profiling only describe the current (or near past) development system(s) in that sport and country. These systems may not be optimal in terms of developing all athletes and other potential systems may be as, or more, effective. Moreover, we are unable to make causal statements about engagement in these various activities and skill acquisition. What is clear from these data, however, is that early childhood involvement in soccer defined all participants; the amount of coach-led practice activity increased linearly across development, as did competition to a far lesser degree, whereas all other activities decreased across adolescence.

In summary, commonalities in the childhood activities of 86 female adult professional soccer players from the national teams of Australia, Canada, England, Sweden and the United States of America were an early start age in the sport, early engagement in soccer, with the majority (78%) showing varying levels of early diversification into other sports. Variation existed between players, with some players diversifying and/or engaging in soccer play to a greater or lesser degree during childhood when compared to the other players. Hours accumulated in coach-led practice increased significantly across age phases, whereas hours accumulated in other sports and soccer
play decreased to low levels by the end of adolescence. Soccer became a full-time activity for the players in adulthood.
References


Table 1. Average age (SD) in years for soccer milestones achieved by national team soccer players from Australia, Canada, England, Sweden, and United States (number of players) and their mean accumulated hours (SD) by 18 years of age.

<table>
<thead>
<tr>
<th>Start age in soccer</th>
<th>Start age in supervised training</th>
<th>Start age in leagues</th>
<th>Start age in academy</th>
<th>Non-soccer training activities</th>
<th>Start age youth international</th>
<th>Start age senior soccer</th>
<th>Start age senior international</th>
<th>Hours in all soccer by 18 years of age</th>
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<tr>
<td>5.4 (1.4)</td>
<td>6.6 (2.2)</td>
<td>7.6 (2.6)</td>
<td>13.6 (3.2)</td>
<td>14.2 (2.5)</td>
<td>15.4 (1.6)</td>
<td>17.1 (2.6)</td>
<td>18.9 (3.2)</td>
<td>6,007 (2,813)</td>
</tr>
</tbody>
</table>
Table 2. The type of other sports engaged in and the number of players who engaged.

<table>
<thead>
<tr>
<th>Type of sport</th>
<th>No. of players</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athletics</td>
<td>45</td>
</tr>
<tr>
<td>Basketball</td>
<td>34</td>
</tr>
<tr>
<td>Swimming</td>
<td>28</td>
</tr>
<tr>
<td>Cross Country</td>
<td>27</td>
</tr>
<tr>
<td>Tennis</td>
<td>20</td>
</tr>
<tr>
<td>Volleyball</td>
<td>19</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>15</td>
</tr>
<tr>
<td>Baseball</td>
<td>12</td>
</tr>
<tr>
<td>Netball</td>
<td>9</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>8</td>
</tr>
</tbody>
</table>
Figure captions

Figure 1. Mean hours accumulated (SD) for all players, in the three soccer activities (practice, play and competition) during childhood (6-12 yr).

Figure 2. Mean hours accumulated (SD) for all players, in the three soccer activities (practice, play and competition) during early (13-15 yr) and late adolescence (16-18 yr).
Soccer activities

**Diagram 1:**

- **Practice:**
  - Hours accumulated: Approximately 2500 hours

- **Competition:**
  - Hours accumulated: Approximately 500 hours

- **Play:**
  - Hours accumulated: Approximately 1500 hours

**Diagram 2:**

- **Practice**
  - Early adolescence: Approximately 1000 hours
  - Late adolescence: Approximately 1500 hours

- **Competition**
  - Early adolescence: Approximately 500 hours
  - Late adolescence: Approximately 1000 hours

- **Play**
  - Early adolescence: Approximately 300 hours
  - Late adolescence: Approximately 500 hours

*Note: The diagrams show a comparison of hours accumulated across different soccer activities and different adolescent stages.*