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8 **The developmental and professional activities of female international soccer players**

9 **from five high-performing nations**

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26 Running head: ACTIVITIES OF FEMALE INTERNATIONAL SOCCER PLAYERS
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34 **The developmental pathways and professional activities of female international**
35 **soccer players from five high-performing nations**

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49 **Abstract**

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

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

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72 **Introduction**

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

81 Deliberate practice theory (Ericsson, 1996; 1998; 2003; 2006; 2007; 2013; Ericsson,
82 Krampe, & Tesch-Römer, 1993; Ericsson & Towne, 2010; Ericsson & Pool, 2016) has
83 been hugely influential in shaping ideas about the development of expert performance.
84 The central parts of deliberate practice theory are the *characteristics of deliberate*
85 *practice* and the *monotonic benefits assumption*. The characteristics of deliberate practice
86 are that it is highly relevant to improving current performance, effortful, and relatively
87 low in inherent enjoyment. The monotonic benefit assumption is that time accumulated in
88 deliberate practice is monotonically related to performance, in that increases in the former
89 lead directly to increases in the latter. Therefore, key claims in the framework first
90 outlined by Ericsson et al. (1993) are that “...the level of performance an individual attains
91 is directly related to the amount of deliberate practice accumulated” (p.370) and that
92 “...individuals who start early and practice at higher levels will have a higher level of
93 performance throughout development than those who start later” (p.392). In sport, these
94 claims have led to the belief that the start of engagement in deliberate practice should

95 occur early in childhood and that children should specialize in a sport so as to maximize
96 time spent in this activity. The American Orthopaedic Society for Sports Medicine
97 (AOSSM) recently published a Consensus Statement (LaPrade et al., 2016) in which they
98 defined three criteria for early sports specialization. First, it involves engagement in
99 intensive practice/training and/or competition for 8 months per year or greater, with low
100 amounts of free play. Second, it involves engagement in a single sport with no
101 participation in other sports. Third, it involves children aged 12 years or younger.

102 Early sports specialization has been associated with negative consequences for those
103 involved, including increased incidence of overuse injuries, social isolation, burnout and
104 dropout during adolescence, as well as reduced success in sports in adulthood (for
105 reviews, see Baker, Cobley, & Fraser- Thomas, 2009; Bergeron et al., 2016; DiFiori et al.,
106 2014; Jayanthi, Pinkham, Dugas, Patrick, & La Bella, 2012; Mostafavifar, Best, & Myer,
107 2013; Rees et al, 2016; Wojtys, 2013). An alternative to early sports specialization is early
108 sports diversification or sampling. The early sports diversification or sampling pathway
109 involves participation in various sports and engagement in deliberate play with no
110 engagement in deliberate practice during childhood (Côté, Lidor, & Hackfort, 2007). As a
111 consequence, specialisation in a single sport is delayed until adolescence. Early sports
112 diversification or sampling is postulated to lead to several positive consequences for those
113 involved, including enhancing intrinsic motivation and other psychosocial variables,
114 reducing overuse injuries, attaining expertise in adulthood, and longer sports careers (for
115 reviews, see Côté & Erickson, 2015; Côté, Horton, MacDonald, & Wilkes, 2009; Côté et
116 al., 2007). Early sports specialisation and diversification are differentiated as pathways to

117 expert performance with their associated consequences in the Developmental Model of
118 Sport Participation (Côté, Baker, & Abernethy, 2007).

119 Deliberate practice theory (e.g., Ericsson et al., 1993) and the
120 specialisation/diversification pathways have been assessed using retrospective recall
121 methods in which the amount of hours spent in developmental activities by expert
122 performers since starting in the domain are recorded via interviews and questionnaires.
123 Multiple researchers have used this method with athletes from a variety of sports and
124 countries (for reviews, see Baker & Young 2014; Güllich & Emrich, 2014). One of the
125 strongest current forms of evidence is from cross-sectional studies involving adult athletes
126 performing at the highest level in their sport separated into groups who are close together
127 on the expertise continuum, such as “world class” versus “national” level adult athletes,
128 albeit the terms used to describe athletes often differs between studies (Berry, Abernethy,
129 & Côté, 2008; Carlson, 1988; Hornig et al., 2016; Law, Côté, & Ericsson, 2007; Güllich,
130 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich & Emrich, 2014; Moesch, Elbe,
131 Hauge, & Wikman, 2011; Van Rossum, 2000; Zibung & Conzelmann, 2013). However,
132 differences in activities between groups close together on the expertise continuum do not
133 necessarily mean those differences caused the groupings. No studies exist involving
134 longitudinal measurement of how all the activities differentially affected skill acquisition
135 during development. Moreover, studies involving samples of adolescent athletes are
136 limited because many of those athletes do not become adult athletes performing at the
137 highest level in their sport, with those athletes confounding the data when assessing the
138 contribution of activities to the development of expert performance. Moreover, “expert-
139 novice” comparisons usually reveal the obvious finding that “experts” have accumulated

140 significantly more sport-specific practice hours compared to “novices” (for a review, see
141 Baker & Young, 2014).

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

157 The early engagement hypothesis (Ford, Ward, Hodges, & Williams, 2009) was
158 created because specialisation/diversification pathways did not adequately explain some
159 of the complexity in developmental activities. In this case, some athletes begin
160 engagement during childhood in the sport they later achieve expertise. In addition, some
161 of those athletes concurrently engage in elements of early diversification, such as peer-led
162 play, which means their developmental activities do not match the early specialisation

163 pathway. However, some athletes engage in elements of early diversification, such as
164 multiple sports, but *do not* engage during childhood in the sport in which they achieve
165 expertise. The early engagement hypothesis was created to differentiate between non-
166 specialising athletes who do or do not engage during childhood in the sport in which they
167 achieve expertise. For example, female and male German national team soccer players
168 started engaging in the sport in childhood (Güllich, 2019; Hornig et al., 2016). Moreover,
169 early engagement is hypothesised to be more likely to occur in sports that are culturally
170 popular, have a high number of participants, are technically demanding, and have a well-
171 developed child sport system (Ford & Williams, 2017).

172 Another contextual factor that may influence the amount and type of developmental
173 activities is gender (Ford & Williams, 2017). Researchers have shown that females in the
174 general population engage in less physical activity during childhood and adolescence
175 compared to males (e.g., Sherar, Esliger, Baxter-Jones, & Tremblay, 2007; Thompson,
176 Baxter-Jones, Mirwald, & Bailey, 2003). These consistent gender-based differences in
177 youth physical activity in the general population suggest that the developmental activities
178 and pathways of female athletes may differ to those reported for their male counterparts.
179 Male and female athletes have been directly compared in a study of national team sport
180 athletes in Australia (Baker, Côté, & Abernethy, 2003). Females had accumulated fewer
181 sport-specific hours during their development, but had greater diversity in sport
182 participation, when compared to their male counterparts. However, in another study of
183 male and female elite Canadian triathletes, time spent in the primary sport during
184 development did not differentiate genders (Hodges, Kerr, Starkes, Weir, & Nananidou,
185 2004). Two other studies have assessed the developmental activities of female athletes.

186 First, female German national team soccer players demonstrated greater engagement
187 across childhood and adolescence in peer-led play in soccer and coach-led other sports,
188 with lower engagement in coach-led soccer practice, later milestones and later
189 specialisation when compared to league players (Güllich, 2019). Second, the female
190 Olympic rhythmic gymnasts studied by Law et al. (2007) accumulated a very high
191 amount of sport-specific practice hours and had low amounts of diversity in other sports
192 in their youth. The mixed results from studies investigating the developmental activities
193 of female athletes suggest further study is required.

194 In the current paper, we study the developmental and professional activities of
195 female adult national team soccer players from around the world. Players were selected
196 from countries playing at the highest level of the sport (international and/or professional),
197 representing the senior national teams of Australia, Canada, England, Sweden and United
198 States of America. Participants completed a questionnaire assessing the number of hours
199 spent in developmental and professional activities since starting in the sport. Their
200 developmental activities during childhood should follow the *early diversification* pathway
201 as per the most-successful adult athletes performing at the highest level in their sport
202 (Berry et al., 2008; Carlson, 1988; Hornig et al., 2016; Güllich, 2014; 2016; 2018; 2019;
203 Güllich et al., 2019; Güllich & Emrich, 2014; Moesch et al., 2011; Van Rossum, 2000).
204 However, the developmental activities of a proportion of players (~25%) were expected to
205 follow the *early specialisation* pathway as reported in some previous studies (Güllich,
206 2014; 2019; Zibung & Conzelmann, 2013), which would be demonstrated by a significant
207 accumulation of hours in soccer during childhood with no or little engagement in other
208 sports. Early engagement in soccer was expected for all players similar to German

209 national team soccer players (Güllich, 2019; Hornig et al., 2016). In addition, the female
210 soccer players were expected to have engaged in increasing amounts of practice in soccer
211 across adolescence, with hours in soccer-specific play and other sports reducing across
212 adolescence, as per previously outlined pathways (Côté, Abernethy et al., 2007). We
213 hypothesized that from late adolescence their activities would involve high volumes of
214 soccer practice commensurate with the deliberate practice framework (e.g., Ericsson et
215 al., 1993).

216 **Method**

217 **Participants**

218 Participants were 86 adult, female, international soccer players in the squads of
219 Australia, Canada, England, Sweden, and the United States of America ($n = 16 - 18$
220 players from each country). Their mean age at the time of data collection was 25.7 yr (SD
221 = 4.1 yr). All the teams were ranked in the top 10 of the Federation Internationale de
222 Football Association (FIFA)/Coca-Cola World Ranking. Players were part of the national
223 squads for their respective countries at the time of data collection and had played at least
224 one official match for their national team ($median = 28$ appearances, $IQ1 = 8$, $IQ3 = 76$,
225 with 11 players over 100 appearances). Informed consent was obtained and the research
226 was conducted according to the ethical guidelines of the lead author's institution [name
227 deleted to maintain the integrity of review process]. [L
SEP]

228 **Questionnaire**

229 The Participation History Questionnaire (PHQ) was used to elicit information
230 relating to the activities that players had engaged in across their developmental and
231 professional years. Indices related to the reliability and validity of the PHQ have

232 previously been reported (e.g., Ford, Low, McRobert & Williams, 2010) and its use is
233 widespread (e.g., Ford et al., 2010; 2012; Ford & Williams, 2012; Winn, Ford, McNarry,
234 Lewis, & Stratton, 2017). The first of the three sections of the questionnaire elicited
235 information on soccer-specific milestones. These included the age at which participants
236 first started playing in soccer of any type, supervised soccer practice, entered a ‘talent
237 development’ training programme (i.e., academy), appeared at youth international level,
238 senior level, senior international level, and in an Olympic Games. Players were required
239 to list their senior honours and the years they occurred. The second section solicited
240 information on engagement in four types of soccer activities: match-play; coach-led
241 practice; individual practice; and non-coach-led play (Côté, Ericsson, & Law, 2005;
242 Ward, Hodges, Starkes, & Williams, 2007). Match-play was defined as organized
243 competition in a group engaged in with the intention of winning and supervised by
244 adult(s) (e.g., league games). Coach-led practice was defined as organized group practice
245 engaged in with the intention of performance improvement and supervised by coach(es)
246 or adult(s) (e.g., practice with team). Non-coach-led individual practice was defined as
247 practice alone engaged in with the intention of performance improvement. This latter
248 category was included because researchers have studied individual practice hours to test
249 ideas relating to deliberate practice theory (Ericsson et al., 1993). Non-coach-led play was
250 defined as play-type games with rules supervised by the player or their peers and engaged
251 in with the intention of fun and enjoyment (e.g., game of soccer in park with friends). The
252 hours/week and months/year in each of the soccer activities, including the number of
253 weeks when players were injured/year, were recorded for a year. Data was recorded for

254 every other year from the current season retrospectively to the under-6 year (U6) age
255 group category.

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

262 **Procedures**

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

270 **Data analyses**

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

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

275 **Activity data.** The hours recorded in soccer activity was recorded for every other
276 year between the current season and start age, so linear interpolation was used for the

277 missing years (i.e., average of the year preceding and succeeding). These hours were split
278 into childhood (6-12 yr), adolescence (13-18 yr), and early adulthood (18-25 yr) stages for
279 practice, play and competition. Soccer-specific practice hours were the sum of individual
280 and team practice, although the number of individual soccer practice hours was relatively
281 low (e.g., in childhood, 62/86 participants reported and accumulated mean 682 hrs, $SD =$
282 623). The accumulated soccer hours within each of the three age stages as a function of
283 soccer activity type were used. The number of other sports and hours accumulated in
284 those other sports were calculated separately for the childhood, adolescence and
285 adulthood stages.

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

290 **Adolescent activities.** To test whether amounts of practice in soccer increased
291 across adolescence, but soccer-play and other sports activity decreased, the activity data
292 were divided into early (13-15 yrs) and late (16-18 yrs) adolescent stages. Hours
293 accumulated in soccer practice and play activities, as well as number of other sports and
294 hours accumulated in other sports, were analysed separately using dependent *t*-tests
295 comparing between age stages (early, late). Bonferroni correction to the alpha level
296 resulted in a significance level of $p < .0125$ for these four *t*-tests. Effect size measures
297 were calculated using partial eta squared (η_p^2).

298 **Adult activities.** Activity data for early adulthood (19-25 yrs) were calculated and
299 are reported as descriptive statistics for any players that had reached 25 years of age.

300 Players younger than 25 years of age were excluded from the adult data.

301 **Results**

302 **Milestones and honours**

303 Table 1 contains the mean age at which players reached soccer-specific
304 milestones. The 86 players started in soccer at a mean age of 5.4 yr ($SD = 1.4$), with every
305 player starting participation in childhood. Players began supervised training at $M = 6.6$ yr
306 ($SD = 2.2$) and in a league a year later ($SD = 2.6$). Of the 78/86 players that reported
307 attending a youth training academy, this occurred at $M = 13.6$ yr ($SD = 3.3$). The first
308 engagement in non-soccer training activities for soccer (such as weights) was at $M = 14.2$
309 yr ($SD = 2.5$). For 78/86 players who reported playing youth international soccer, their
310 first appearance was at $M = 15.4$ yr ($SD = 1.6$ yr). The 86 players started in senior soccer
311 at $M = 17.1$ yr ($SD = 2.6$). Players went on to achieve several honours in senior soccer
312 and all achieved at least one appearance for their senior national team (*median* = 28
313 appearances, $IQ1 = 8$, $IQ3 = 76$, with 11 players over 100 appearances) at the time of data
314 collection (2012/13). They first played for their national team at $M = 18.9$ yr ($SD = 3.2$)
315 and 51/ 86 players first played at an Olympic Games at $M = 24.0$ yr ($SD = 4.8$). All
316 players represented the senior team of a professional club. Honours included at the time of
317 data collection included at least one Olympic Games medal for 29 players and World Cup
318 winners or runner-up medals for 24 players, with 39 players winning national
319 championships with their clubs. Many of the players have won more of these honours for
320 both club and country in the intervening time period since data collection.

321 **Childhood activities**

322 During childhood (6-12 yr), players accumulated an average of 2,519 hr ($SD =$
323 1,861) in all soccer-specific activities, which equals an average of 7.2 hr/wk over each of
324 seven, 50-week years during this period. Altogether, 80/86 players engaged in other sports
325 during childhood. They engaged in $M = 3.2$ sports ($SD = 1.9$) and accumulated $M = 1,040$
326 hr ($SD = 908$) across this period, equating to an average of 3.0 hr/wk. Start age in other
327 sports varied across childhood ($median = 9$ yr; $IQ1 = 7$; $IQ3 = 12$ yr). It should be noted
328 that there was variation in the data for hours accumulated during childhood. Altogether,
329 12/86 players (14%) accumulated more hours during childhood in other sports compared
330 to soccer, whereas only 2/86 did so in adolescence. There were three other players whose
331 hours accumulated in other sports during childhood were 300 hrs or less below those in
332 soccer. For these 15/86 players (17%) of players, their mean number of other sports was
333 3.8 sports ($SD = 1.4$). In contrast, 19/86 players (22%) accumulated less than 300 hours in
334 other sports during childhood, with 6 of those players not engaging in other sports during
335 this period (7%). The mean accumulated hours in soccer activity during childhood for
336 these 19 players was 1,840 hrs ($SD = 1,032$).

337 Figure 1 shows the hours accumulated in the three soccer activities during
338 childhood. There was a significant difference in hours accumulated between the three
339 soccer activities, $F_{2, 164} = 18.48$, $p < .01$, $\eta_p^2 = .18$. *Post-hoc* tests showed that hours in
340 competition ($M = 361$ hrs, $SD = 383$ hr) were lower (p 's $< .01$) compared with practice (M
341 $= 1,337$, $SD = 1,087$ hr), and play ($M = 911$, $SD = 1,393$ hr), but there was no difference
342 between practice and play ($p = .11$). However, 20/86 players (23%) did not engage in play
343 during childhood (values = 0 hrs). The mean for the 66 players who did was 1,146 hrs

344 ($SD = 1,474$). Variation was noted in these data for soccer activities and pathways. Soccer
345 activity during childhood occurred more so in coach-led settings compared to peer-led
346 play, but 16 players (19%) accumulated more hours during childhood in soccer-specific
347 play compared to practice, whereas only 4 did so in adolescence (5%). When assessing
348 childhood sports activity data as a whole and, specifically, players who *specialised early*,
349 there were 19/86 players (22%) who engaged solely in soccer activity (when using less
350 than 300 hrs accumulated in other sports during childhood to categorise).

351 **Adolescence**

352 **Soccer activities.** Figure 2 shows the hours accumulated in the three soccer
353 activities during adolescence. Players accumulated $M = 3,489$ hrs (11.6 hr/wk across six
354 50-week years; $SD = 1,836$) in soccer activities across this period. Hours accumulated in
355 soccer practice were greater in late ($M = 1,303$ hrs across 3 years / 8.7 hr/wk across 50-wk
356 years, $SD = 638$) compared to early adolescence ($M = 1,002$ hrs across 3 years / 6.7 hr/wk
357 across 50-wk years, $SD = 648$), $t_{85} = 6.86$, $p < .0125$. Hours accumulated in soccer play
358 were lower in late ($M = 219$ hrs, $SD = 514$) compared to early adolescence ($M = 377$ hrs,
359 $SD = 750$), $t_{85} = 4.45$, $p < .0125$. However, 28 and 32 players did not engage in soccer
360 play during early and late adolescence, respectively. The actual mean for the 58 players
361 who did engage in play during early adolescence was 560 hrs (3.7 hr/wk, $SD = 857$) and
362 for the 54 players in late adolescence, $M = 350$ hrs (2.3 hr/wk, $SD = 615$). Hours
363 accumulated during adolescence in soccer competition were 587 hrs (2.0 hr/wk across six
364 50-wk years, $SD = 367$).

365 Up to the age of 18 yr, which is the mean age that the 86 players first represented
366 their national team, they accumulated an average of 6,007 hr ($SD = 2,813$) in all soccer
367 activities (sum of practice, play and competition).

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

381 **Adulthood**

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

388 Discussion

389 We evaluated the developmental and professional activities of female adult national
390 team soccer players. Our aim was to determine the activity pathways of these players in
391 relation to existing developmental pathways and previous data from male players. Given
392 early diversification characterises the developmental activities of the most-successful
393 adult athletes performing at the highest level in their sport (Berry et al., 2008; Carlson,
394 1988; Hornig et al., 2016; Güllich, 2014; 2016; 2018; 2019; Güllich et al., 2019; Güllich
395 & Emrich, 2014; Moesch et al., 2011; Van Rossum, 2000), we expected to find the same
396 in our sample. In addition, childhood engagement in soccer was expected for all players
397 similar to German national team soccer players (Güllich, 2019; Hornig et al., 2016).
398 However, early specialisation was expected for around a quarter of all players similar to
399 previous studies with soccer players (Güllich, 2019; Zibung & Conzelmann, 2013). We
400 anticipated increasing amounts of practice hours from early adolescence onwards.

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

410 as between adolescence and adulthood. Hours accumulated in other sports, soccer-specific
411 play, and number of other sports decreased in the same manner.

412 The start age in soccer for all players was in early childhood (~ 5 yr), similar to start
413 ages for elite, male players (Ford et al., 2009; 2012; Hendry, Crocker & Hodges, 2014;
414 Hendry & Hodges, 2018; Hornig et al., 2016; Ward et al., 2007) and German female
415 national team players (Güllich, 2019). During childhood, the players averaged 7 hrs/wk of
416 soccer activity, again similar to previous research with elite, males (Ford et al., 2012;
417 Hornig et al., 2016; Ward et al., 2007) and German female national team players (Güllich,
418 2019). Their start age in a youth training academy occurred in early adolescence ($M =$
419 13.6 yr) slightly later compared to male players (e.g., 12 yrs, Ford et al., 2012). This
420 suggests that the early engagement in soccer activity mainly occurred at a recreational
421 level and that the academy system for females recruits later compared to males. In
422 addition, during childhood, the players engaged in an average of three other sports during
423 childhood for around 3 hrs per week, supporting other research showing early
424 diversification with early engagement (Berry et al., 2008; Carlson, 1988; Hornig et al.,
425 2016; Güllich; 2019; Güllich et al., 2019; Moesch et al., 2011).

426 As expected, across adolescence, players increased hours in coach-led, soccer
427 practice and decreased hours in soccer play and other sports, as well as having a median
428 end age in other sports of 14 yrs, supporting data from elite, male (e.g., Ford et al., 2012;
429 Hornig et al., 2016; Ward et al., 2007) and female players (Güllich, 2019). This pattern of
430 results would be predicted based on deliberate practice theory (Ericsson et al., 1993) and
431 both pathways outlined in the DMSP (Côté, Abernethy et al., 2007). It is similar to other
432 studies of expert athletes (Berry et al., 2008; Carlson, 1988; Güllich, 2016; Hornig et al.,

433 2016). By 18 year of age, mean hours accumulated in all soccer activity were 6,007 hrs
434 ($SD = 2,813$), which is lower when compared to German male national team players
435 (Hornig et al., 2016), but is similar to German female national team players (Güllich,
436 2017) and their male Olympic Champion field hockey team (Güllich, 2014).

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

451 One explanation for variation in hours accumulated in activities between expert
452 performers during their development is that differences exist in the “quality” of those
453 activities, with various activities contributing to a greater or lesser degree to skill
454 acquisition (for a review, see Ford, Coughlan, Hodges, & Williams, 2015). A limitation of
455 the current study is that we only examined engagement in macro-activities (practice, play,

456 competition). We did not study the microstructure of these activities, which would likely
457 provide richer information about the effects of those activities (for a review, see Hendry,
458 Ford, Williams, & Hodges, 2015). Another limitation of this study is that no measure of
459 player performance or outfield position was included, so the observed variation could be
460 attributable to player skill and position. Although this study is informative in helping
461 describe developmental pathways that have preceded success in female soccer, it is
462 important to remember that studies based on practice history profiling only describe the
463 current (or near past) development system(s) in that sport and country. These systems
464 may not be optimal in terms of developing all athletes and other potential systems may be
465 as, or more, effective. Moreover, we are unable to make causal statements about
466 engagement in these various activities and skill acquisition. What is clear from these data,
467 however, is that early childhood involvement in soccer defined all participants; the
468 amount of coach-led practice activity increased linearly across development, as did
469 competition to a far lesser degree, whereas all other activities decreased across
470 adolescence.

471 In summary, commonalities in the childhood activities of 86 female adult
472 professional soccer players from the national teams of Australia, Canada, England,
473 Sweden and the United States of America were an early start age in the sport, early
474 engagement in soccer, with the majority (78%) showing varying levels of early
475 diversification into other sports. Variation existed between players, with some players
476 diversifying and/or engaging in soccer play to a greater or lesser degree during childhood
477 when compared to the other players. Hours accumulated in coach-led practice increased
478 significantly across age phases, whereas hours accumulated in other sports and soccer

479 play decreased to low levels by the end of adolescence. Soccer became a full-time activity

480 for the players in adulthood.

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637

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.

<i>Start age in soccer</i>	<i>Start age in supervised training</i>	<i>Start age in leagues</i>	<i>Start age in academy</i>	<i>Non- soccer training activities</i>	<i>Start age youth international</i>	<i>Start age senior soccer</i>	<i>Start age senior international</i>	<i>Hours in all soccer by 18 years of age</i>
5.4 (1.4)	6.6 (2.2)	7.6 (2.6)	13.6 (3.2)	14.2 (2.5)	15.4 (1.6)	17.1 (2.6)	18.9 (3.2)	6,007 (2,813)

Table 2. The type of other sports engaged in and the number of players who engaged.

<i>Type of sport</i>	<i>No. of players</i>
Athletics	45
Basketball	34
Swimming	28
Cross Country	27
Tennis	20
Volleyball	19
Gymnastics	15
Baseball	12
Netball	9
Field Hockey	8

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).

