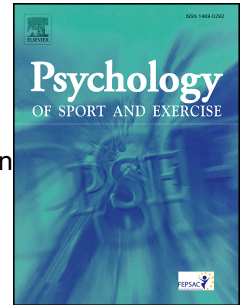


# Accepted Manuscript

Developmental activities and perceptions of challenge for National and Varsity women soccer players in Canada

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PII: S1469-0292(18)30480-1

DOI: <https://doi.org/10.1016/j.psychsport.2019.02.008>

Reference: PSYSPO 1493

To appear in: *Psychology of Sport & Exercise*

Received Date: 3 August 2018

Revised Date: 22 February 2019

Accepted Date: 23 February 2019

Please cite this article as: Hendry, D.T., Williams, A.M., Ford, P.R., Hodges, N.J., Developmental activities and perceptions of challenge for National and Varsity women soccer players in Canada, *Psychology of Sport & Exercise* (2019), doi: <https://doi.org/10.1016/j.psychsport.2019.02.008>.

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**Developmental activities and perceptions of challenge for National and Varsity women  
soccer players in Canada**

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### Abstract

*Objectives:* Our aim was to assess the developmental activities that best define elite players in female soccer in one of the top nations for female soccer in the world. In addition to measurement of career practice hours in soccer and other sports, we quantified hours engaged in activities judged high in challenge.

*Design and methods:* Adult National-team ( $n = 21$ ) and lesser-skilled Varsity ( $n = 24$ ) female soccer players in Canada provided career estimates of hours in soccer and other sports during childhood and adolescence. Subjective ratings of challenge were provided for each activity across development, providing an indication of practice quality.

*Results:* Both groups engaged in more coach-led soccer activities (practice, competition) than soccer play and spent the majority of their time in childhood in soccer compared to other sports. National players participated in more play that was more challenging and engaged in more moderate to high challenge practice, when compared to Varsity players.

*Conclusions:* The importance of early engagement in soccer specific developmental activities for elite female soccer players in Canada was highlighted, as previously reported in male players. However, hours in soccer play during childhood were low in both groups and were lower than estimates from male players. Although the data do not fit squarely with any one pathway, they are mostly consistent with an early specialization route.

**Keywords:** practice; development; talent; football; skill; expertise

30           **Developmental activities and perceptions of their challenge for National and Varsity**  
31                           **women soccer players in Canada**

32           Women's soccer is rapidly growing in popularity with approximately 30 million  
33 participants worldwide, making it one of the most popular female sports (FIFA, 2015).  
34 Paradoxically, there remains a paucity of research focusing on the developmental activities  
35 engaged in by elite female players that could be used as normative data to guide future  
36 generations of elite players (Gledhill & Harwood, 2014). Our current knowledge is largely  
37 derived from research on elite and sub-elite male soccer players (e.g., Ford, Ward, Hodges, &  
38 Williams, 2009; 2012; Ford & Williams, 2012; Hugaasen & Jordet, 2012; Hendry, Crocker &  
39 Hodges, 2014; Hornig, Aust, & Güllich, 2016; Zibung & Conzelmann, 2013). It remains unclear  
40 whether these findings from male players are generalizable to female players (Gill, 2001). In this  
41 paper, we present data on the career practice histories of National and Varsity women soccer  
42 players in Canada, with respect to soccer play, practice, and competition, as well as involvement  
43 in other sports. In an attempt to better capture differences between various sport-related activities  
44 and potentially the quality of the practice (cf., Coutinho et al., 2016; Ericsson & Poole, 2016;  
45 Ford et al., 2015), players estimated perceptions of challenge associated with these activities  
46 across development (Guadagnoli & Lee, 2004).

47           There has been some qualitative research directed at uncovering the developmental  
48 experiences of elite National female soccer players in England (Gledhill & Harwood, 2014). One  
49 developmental activity viewed by the players as beneficial to later success was early competition  
50 experience involving male players at ~10-12 yr. Competitive, co-recreation opportunities tended  
51 to cease from 12-14 yr, at which point elite players participated in organized female-only teams.  
52 However, because this study had a broad focus on a variety of developmental experiences, such

53 as family influences, limited information was provided on developmental activities. Moreover,  
54 there is reason to suspect that the developmental activities and experiences of female soccer  
55 players in England would be different to that of North American players. In England,  
56 participation opportunities for organized soccer among girls is relatively new, whereas female  
57 participation in youth soccer has been a popular, high participation sport for many years in North  
58 America (FIFA, 2007; The Football Association, 2018).

59 Several researchers have used deliberate practice theory (Ericsson, Krampe, & Tesch-  
60 Römer, 1993) and the Developmental Model of Sports Participation (DMSP; Côté, Baker, &  
61 Abernethy, 2007; Côté, Murphy-Mills, & Abernethy, 2012; Côté, 1999) as a basis to evaluate the  
62 developmental pathways for elite, mainly male, athletes (for reviews of the literature on soccer,  
63 see Haugaasen & Jordet, 2012; Ford & Williams, 2017). The DMSP comprises two pathways  
64 that could lead to expert performance. The *early specialization* pathway is based upon high  
65 volumes of sport specific practice from an early age (~5-12 yr), through adolescence and into  
66 adulthood, with little or no engagement in other sports or play. Post and colleagues (2017) have  
67 further defined specialization as engagement in more hours of single sport activity per week,  
68 than the athlete's current age, for a minimum of 8 months of the year. In contrast, the early  
69 diversification pathway involves high volumes of play and multisport activity during childhood,  
70 with specialization in the primary sport occurring in adolescence. Relevant to these pathways,  
71 deliberate practice activities are typically viewed as structured, coach-determined practice  
72 activities, engaged in with the primary intention of improvement (Ericsson, Krampe, & Tesch-  
73 Römer, 1993; Ericsson & Pool, 2016). In comparison, play comprises unstructured, peer-led  
74 sport-specific activities, engaged for the primary purpose of enjoyment (Côté, 1999; Côté &  
75 Erickson, 2015; Côté et al., 2012).

76           Although the DMSP outlines two potential pathways leading to success in elite athletes,  
77 these pathways do not fully align with published research involving male soccer players (e.g.,  
78 Ford et al., 2009; 2012; Ford & Williams, 2012; Haugaasen & Jordet, 2012; Hendry & Hodges,  
79 2018; Hornig et al., 2016; Sieghartsleitner, Zuber, Zubung & Conzelmann, 2018). In general,  
80 elite male soccer players follow what has been termed an *early engagement* pathway (Ford et al.,  
81 2009; 2012; Hendry & Hodges, 2018). In this pathway, childhood activities are characterised by  
82 majority engagement in one sport through both coach-led practice and non-coach-led play  
83 activities. For example, professional soccer players tracked across youth developmental  
84 academies in the United Kingdom (UK) engaged in a majority of soccer practice (e.g., team  
85 practice) in comparison to multisport practice in childhood (Hendry & Hodges, 2018). Although  
86 the players that attained adult professional status engaged in several other sports during  
87 childhood, they engaged in significantly fewer sports than elite youth players that did not attain  
88 professional status. The future adult professional players accumulated more hours in soccer play  
89 (e.g., street soccer) in comparison to youth professionals that were not selected to play at adult  
90 professional levels. It is likely that this early engagement pathway, which places particular  
91 emphasis on domain specific activity (see also Sieghartsleitner et al., 2018), best defines team  
92 sports where participation rates and competition to succeed are high (e.g., men's soccer in the  
93 UK, Europe and South America and men's ice-hockey in Canada; see Ford & Williams, 2017).  
94 Since participation and competition are lower in women's soccer, it is unclear which pathway  
95 (early specialization, early engagement or diversification) best defines elite success in female  
96 soccer players.

97           While much of the research used to identify the developmental trajectories of elite  
98 athletes is based on estimates of activity quantity to good effect, this volume-based method has

99 been limited as it fails to provide information about activity quality during development (see  
100 Ford et al., 2015). Not all practice sessions or play experiences are equal, with the quality of the  
101 learning experience related to several factors including: player engagement, type of instruction,  
102 the temporal-spatial demands of the task, and the resultant taxation of players' perceptual,  
103 cognitive and motor capabilities (e.g., Hendry & Hodges, 2013; Hendry et al., 2015). One  
104 possible method of assessing practice quality is outlined within the challenge-point framework  
105 which has its roots in the motor learning literature (Guadagnoli & Lee, 2004). According to this  
106 framework, there is a theoretically optimal challenge point that emerges when the constant  
107 degree of task difficulty (e.g., side volley with non-dominant foot) is equal to, or slightly higher  
108 than, the skill level of the learner relative to the task (e.g., ability of players to use their non-  
109 dominant foot). At this individual challenge point, the learner is thought to be processing an  
110 optimal amount of information to maximise the potential for skill acquisition. When task  
111 difficulty is low relative to the individuals' skill, learning is sub-optimal but performance is high.  
112 Also, when task difficulty is too high, learning is not optimal because the task demands exceed  
113 current capabilities/attention capacities. Thus optimal challenge can shift so that as the skill of  
114 the learner improves, so does the degree of task difficulty required to optimize skill acquisition.

115 In many respects, the challenge point framework is analogous to some of the components  
116 of deliberate practice theory, in which expertise is achieved by continuously progressing practice  
117 to stretch the limits of current capacities. One of the major differences between deliberate  
118 practice and play is based upon the intention of the participant. For play, the primary intention is  
119 to experience fun and enjoyment, whereas for practice, the primary intention is performance  
120 improvement. However, skill acquisition can emerge as a by-product from engagement in play,  
121 especially in the earlier stages of participation, irrespective of any specific intention. For



122 example, in soccer, positive associations have been demonstrated between soccer play amounts  
123 in childhood and later soccer expertise (Ford et al., 2009; 2012; Ford & Williams, 2012; Hornig  
124 et al., 2016). Therefore, it may be that the difficulty of the task relative to the learner, whether in  
125 play, practice or competition, is as, or more, important than the specific intention behind  
126 engagement in the behaviour. An assessment of the individualized degree of challenge associated  
127 with each developmental activity at different milestones would provide one measure of the  
128 quality of the activity (regardless of the type) and may relate to later expertise. Although it is  
129 likely that players with intentions to improve will more likely seek out high challenge situations,  
130 high challenge is not always a characteristic of practice, whereas play activities are not  
131 necessarily less challenging than those encountered in practice.

132         Some researchers have proposed that experience in competition is a key part of the  
133 development of expertise in sport (Abernethy, Farrow, & Berry, 2003; Singer & Janelle, 1999).  
134 In youth development in soccer, competition is often viewed as an extension of practice in which  
135 the experience of playing against various opponents in varied environments benefits skill  
136 acquisition (Cook, Crust, Littlewood, Nesti, & Allen-Collinson, 2014; Ford, 2016). In contrast,  
137 competition in deliberate practice theory is viewed as “work”, with the assumption that it is  
138 motivated by external rewards and lacks opportunities for experimentation and feedback  
139 (Ericsson et al., 1993). In support of this view, time spent in competition is not usually a  
140 discriminatory variable in youth soccer domains (e.g., Ford et al., 2012, 2009; Ford & Williams,  
141 2012). This finding is likely a function of the fact that leagues or organizations often externally  
142 control the number and duration of games. However, it may be that it is the degree of relative  
143 challenge experienced during competition that distinguishes across skill groups. If the  
144 challenging nature of the activity is a good measure of its quality, then hours spent in soccer

145 activities that are judged to be challenging, (i.e., activities that are moderate to highly demanding  
146 relative to the athlete's skill), will differentiate across skill groups and potentially provide greater  
147 discriminability than assessments based upon accumulated soccer activity hours alone.

148 The primary aim of this study was to determine the hours accumulated in developmental  
149 activities in soccer and other sports during childhood (5-12 yr) and adolescence (12-18 yr) and  
150 compare across National and Varsity women soccer players in Canada. A secondary aim was to  
151 determine whether greater discriminability could be achieved by comparing hours in these  
152 activities based on moderate to high perceived task difficulty (i.e., optimally challenging). In  
153 accordance with the development pathways engaged in by elite male soccer players, we expected  
154 that National female players would participate in higher volumes of soccer practice and play  
155 compared to female Varsity athletes. However, we were uncertain as to whether developmental  
156 profiles would primarily be characterised by an early specialisation or engagement profile (as  
157 seen in male soccer) or by a more diversified sport involvement. We anticipated that the more  
158 elite players (National) would have engaged in more optimally challenging (i.e., moderate to  
159 high challenge) developmental activities during childhood and adolescence than the Varsity  
160 players.

## 161 **Methods**

### 162 **Participants**

163 Participants were female, soccer players ( $N = 45$ ), consisting of 21 National and 24  
164 Varsity level players in Canada. National players ( $M$  age = 28.26,  $SD = 3.95$  yr) were  
165 participating at the international level, ranked within the top 10 national teams in the world (and  
166 all of whom had competed in Olympic competition). Because of the exhaustive nature of our  
167 sample (i.e., our current sample were almost a complete representation of the Canadian National

168 women's team), we were limited by the number of athletes that could be recruited. This naturally  
169 causes issue for power and as such, some caution is needed in interpretation. Based on an a priori  
170 power analysis (G\*Power; Erdfelder, Faul, & Buchner, 1996), we would have needed  $n = 33$   
171 athletes in each sample (based on  $1-\beta = .80$ ; 2 X 2 mixed-design ANOVA, with Bonferroni  
172 adjusted alpha of .017 and the smallest effect size based on elite male soccer activity volumes;  
173  $\eta_p^2 = .04$ / Cohen's  $f = .20$ ; Hendry & Hodges, 2018). Because of the highly elite nature of the  
174 sample and the scarcity of research within female soccer, we felt that continuation with the study  
175 was merited. In an effort to keep some homogeneity in variance between samples, our Varsity  
176 group was based on a similar sample size.

177 Varsity level athletes ( $M$  age = 19.60,  $SD = 1.31$  yr) were currently competing at the  
178 highest level of soccer in the university system in Canada. No Varsity player had played or was  
179 expected to play adult-National team soccer, albeit  $n = 10$  had represented Canada at various  
180 youth levels. As such, these were two highly elite groups of players representing the top two-  
181 tiers of adult women's soccer in Canada. Although all participants were adults, the National  
182 players were ~8 yr older than the Varsity players at the time of data collection,  $t(43) = 7.21$ ,  $p <$   
183  $.001$ ,  $d = 2.17$ . Participants provided written informed consent. All procedures adhered to the  
184 lead institution's REB guidelines and participants were given a \$10 gift card for participation.

### 185 **Procedures and Measures**

186 Contact was initially made with representatives from the National and Varsity teams via  
187 email correspondence before players were approached. After a briefing on the purpose of the  
188 study and the provision of informed consent, participants completed a series of questionnaires to  
189 provide information pertaining to soccer milestones, developmental soccer activities and  
190 developmental activity challenge. These were completed in small groups, in rooms supervised by

191 members of the research team who provided clarification of all operational definitions including  
192 soccer activity type and optimal challenge. The questionnaires took approximately 45 min to  
193 complete.

194 *Participation History Questionnaire (PHQ)*: The PHQ has been shown to provide valid  
195 and reliable estimates of the developmental activities engaged in by athletes (e.g., Ford, Low,  
196 McRobert, & Williams, 2010). This type of retrospective questionnaire method is regarded as  
197 one of the best available methods for obtaining data on the developmental activity histories of  
198 elite athletes (Hopwood, 2015). The PHQ consists of three sections. In section one, basic  
199 demographic information pertaining to start age in soccer, supervised soccer practice, soccer  
200 competition, and participation in an elite development program was solicited. Further questions  
201 with respect to start age in co-ed soccer (i.e., playing on boy's teams or with boys) and age of  
202 entry into a national youth team set-up were included.

203 The second section of the PHQ elicited information relating to estimates of hours in  
204 developmental soccer activities. Four activities were listed based upon previous research (e.g.,  
205 Côté, Ericsson, & Law, 2005; Ford et al., 2009). These included 'match-play' (organized  
206 competition usually between two teams supervised by adult/s and engaged in with the intention  
207 of winning), 'coach-led practice' (organized group practice supervised by coach/adult engaged in  
208 with the intention of performance improvement), 'individual practice' (practice alone, engaged  
209 in with the intention of performance improvement), and 'soccer play' (play-type games with  
210 rules supervised by oneself or peers and engaged in with the intention of fun and enjoyment,  
211 such as street or playground soccer). Athletes recorded information pertaining to participation in  
212 structured, coach-led practice in other sports outside of physical education classes.

213 For each component, players recorded: (i) number of sessions/week; (ii) average duration  
214 of each session; (iii) and months per year participating. We elicited estimates for a typical week  
215 of soccer activity (practice, play, and competition) through the youth development phase from  
216 Under 6 (U6) to U19 age group categories in 2 year intervals (i.e., 5–6 yr (Under 6), 7–8 yr (U8),  
217 up to 18-19 (U19) yr). The categorization of age groups is determined by a cut off date, normally  
218 January 1<sup>st</sup> in the selection year. With the season generally starting in September, this means that  
219 U6 players will turn 6 yr at different points throughout the season. Thus, we have data ranging  
220 from 5 yrs to 19 yr. To aid recall and prevent inflation of estimates associated with starting at  
221 the earliest date, players gave estimates in reverse chronological order and were first asked to  
222 recall who their coach was at the various age groupings. Linear interpolation methods were used  
223 to estimate values in intervening years. The hours accumulated in all soccer and other sport  
224 activities were calculated by multiplying the number of hours/session by the number of  
225 sessions/week and months/yr. Significant breaks through illness/injury were recorded and  
226 subtracted from yearly estimates. From these estimates, the accumulated hours in soccer and  
227 other sport practice activities were calculated for childhood (5-12 yr) and adolescence (13-18 yr).

228 *Perceptions of challenge:* Alongside each weekly soccer activity estimate, participants  
229 recorded the recalled degree of challenge associated with each activity relative to their own skill  
230 level at that time-point. The research team explained that challenge related to the balance  
231 between their current skill level versus the difficulty/challenge associated with the activity and  
232 playing against others in that activity at that time. Optimal challenge was operationally defined  
233 as moderate to high-challenge and to represent activities that “continually test your abilities, that  
234 are demanding and/or stimulating.” Participants were asked to provide ratings of the challenge  
235 (i.e., difficulty of the activity in relation to their own skill) for each soccer activity, at every age

236 group, using a 5-point scale (0 = Not at all challenging/easy, 1 = Some /low challenge, 2 =  
237 Moderate challenge, 3 = High challenge, 4 = Too much challenge/extremely challenging).

### 238 **Statistical analyses**

239 The data were checked for normality using the Shapiro-Wilk test. When the magnitude of  
240 skewness was less than 1, indicating only a tendency towards positive skewness (Bulmer, 1979),  
241 and there were no significant group differences in homogeneity of variance, we used parametric  
242 methods (Glass, Peckham, & Sanders, 1972; Pallant, 2007). In cases where assumptions were not  
243 met (i.e., for estimates of practice hours in soccer and multisport activities), we performed a log<sub>10</sub>  
244 transformation to normalize data before analysis (Tabachnick & Fidell, 2007). Confidence  
245 intervals (95%) around the mean difference are reported for all pairwise comparisons. Since  
246 ~38% of athletes did not engage in individual practice from U6 to U11 yr and only ~20%  
247 engaged in individual practice from U12 – U16 yr, we combined individual and coach-led  
248 practice estimates. Individual and team practice have been combined in the past to reflect  
249 deliberate practice activities (e.g., Helsen et al., 1998; Ford et al., 2009). However, we conducted  
250 separate analyses on these data, as noted in Footnote 1, to show that the groups did not differ  
251 with respect to individual practice amounts and that changing the analysis to consider individual  
252 practice as a self-led “play-type” activity, would not have changed the overall pattern of results<sup>1</sup>.

253 *Developmental activity milestones:* We compared across the skill groups (National,  
254 Varsity), for five major soccer milestones, using independent t-tests with Bonferroni adjustments  
255 ( $p = .05/5 = .01$ ). Comparisons were made for start age in structured and unstructured soccer  
256 activities, age of entry into an elite development practice setting (i.e., academy) and age of  
257 national youth team selection. Based on start and end age in co-recreation organized soccer, we  
258 calculated duration (in yr) of co-rec participation.

259            *Developmental activity hours:* Three separate 2 Skill x 2 Age period (childhood,  
260 adolescence) ANOVAs, with repeated measures on the last factor, were used to ascertain  
261 differences in either accumulated practice, play or competition hours. Any significant  
262 interactions were followed up with Bonferroni-corrected, pairwise comparisons. We undertook  
263 comparisons between soccer practice hours and practice in other sports using a 3-way ANOVA,  
264 with Activity as a second RM variable (both practice variables were log-transformed before  
265 analysis). The number of other sports participated in during childhood and adolescence were  
266 compared in a 2 Skill x 2 Age Period ANOVA (after log transformation).

267            *Challenge ratings:* We calculated mean challenge ratings by aggregating the mean  
268 individual challenge score for each activity across each year for childhood and adolescence age  
269 periods. Comparisons were made across practice, play and competition using three separate 2  
270 Skill x 2 Age period ANOVAs. Using the challenge ratings, we calculated accumulated hours in  
271 “optimally challenging” activities, defined as moderate to high challenge soccer activities  
272 (ratings of 2 and 3) for each activity and compared these in similar 2-way ANOVAs (with  
273 Bonferroni adjusted  $p$  values,  $.05/3 = .017$ ).

274            *Player-player reliability:* Two separate sections of the questionnaire were compared,  
275 where we had asked for estimates of hr/week in current coach-led practice. In the first section,  
276 players provided an overall estimate of hr/week in soccer coach-led practice, whereas in the  
277 second, players provided separate entries for number of sessions/week and hours/session. The  
278 strength and similarity of these weekly activity estimates were assessed with intra-class  
279 correlation ( $ICC$ ) using Cronbach’s alpha and percent agreement ( $PA$ ) scores respectively. This  
280 combination of analyses, has been recommended for the assessment of validity and reliability of  
281 activity estimates (Atkinson & Neville, 1998; Hopwood, 2015).  $ICC$ ’s were also used to assess

282 the within-person reliability of challenge ratings for each activity across the developmental  
283 period (U6-U19 yr), with the assumption that although these would change across time, they  
284 should remain relatively consistent on an individual level. We also ran ICCs on each activity  
285 (practice, play and competition) for each year, assuming that there would be a degree of within-  
286 person consistency across the activities within each developmental age-group. Of course,  
287 because these measures of reliability were not assessing the same things twice, these only give an  
288 approximate insight into consistency in ratings across individuals.

289 For any significant ANOVA interactions, post-hoc pairwise comparisons were applied  
290 with Bonerroni corrections. Greenhouse Geisser df corrections were applied to sphericity  
291 violations across all analyses. Partial eta-squared values are reported for significant ANOVAs  
292 and Cohen's  $d$  as a measure of effect size for pairwise comparisons. The alpha level for  
293 significance was set at  $p < .05$ , unless otherwise indicated.

## 294 Results

### 295 Developmental activity milestones

296 The ages at which the National and Varsity players reached various milestones in soccer  
297 are presented in Table 1. The players started in soccer during early childhood (~ 5 yr) but start  
298 age did not differ across groups. The age of participation in structured soccer practice,  $t(43) =$   
299  $2.43, p = .02, d = .78, M_{difference} = 1.23$  yr, 95% CI [.02, 2.23] and start age in an Academy,  $t(44)$   
300  $= 2.58, p = .02, d = .89, M_{difference} = 3.28$  yr, 95% CI [1.02, 5.54], occurred at a later age for the  
301 National when compared to the Varsity group, but these differences were not statistically  
302 significant based on Bonferroni corrected  $p$  values. The number of National ( $n = 15$ ) and Varsity  
303 players ( $n = 14$ ) that had played co-recreational soccer as a child and the average number of  
304 years played did not differ,  $t(27) = 1.21, p = .23, d = .04, M_{difference} = .58$  yr, 95% CI [-1.16, 4.72].



305 There were no differences in terms of start age in a youth international team,  $t(27) = 1.69$ ,  $p =$   
306  $.10$ ,  $d = .04$ ,  $M_{\text{difference}} = 2.14$  yr, 95% CI [-4.75, .46], albeit only  $n = 10$  Varsity players attained  
307 this level in comparison to  $n = 18$  of the National players.

308 The National players participated in fewer sports than the Varsity players,  $F(1,44) = 7.43$ ,  
309  $p = .01$ ,  $\eta_p^2 = .14$ ,  $M_{\text{difference}} = 2$  sports, 95% CI [0.64, 3.42] and this did not differ across age  
310 categories,  $F(1,44) = 1.05$ ,  $p = .31$ ,  $\eta_p^2 = .02$  (see Table 1).

### 311 **Developmental activity hours**

312 The mean accumulated hours in soccer activities across the developmental timespan are  
313 presented in Figures 1a, b and c (5-19 yr, that is, U6-U19 yr age-groups). RM ANOVAs  
314 comparing across the childhood and adolescence periods only showed skill-group differences in  
315 accumulated hours in soccer play,  $F(1, 44) = 13.62$ ,  $p = .01$ ,  $\eta_p^2 = .26$ , but not in practice or  
316 competition ( $F_s < 1$ ). The National players accumulated more hours in soccer play compared to  
317 Varsity players,  $M_{\text{difference at 19 years}} = 519.3$  hr, 95% CI [220.9, 817.6]. There were significant age  
318 period differences for accumulated hours in soccer practice,  $F(1, 44) = 23.09$ ,  $p = <.001$ ,  $\eta_p^2 =$   
319  $.37$ ,  $M_{\text{difference}} = 1045.8$  hr, 95% CI [768.5, 1323.2] and competition,  $F(1, 44) = 38.09$ ,  $p = <.001$ ,  
320  $\eta_p^2 = .49$ ,  $M_{\text{difference}} = 204.9$  hr, 95% CI [132.7, 276.4], but not soccer play ( $F < 1$ ). More hours  
321 were accumulated in adolescent practice and competition than in childhood. There were no  
322 significant interactions involving skill groups. For reference, by 19 years of age, the National ( $M$   
323  $= 8361.6$  hrs,  $SD = 5016.96$ ) and Varsity players ( $M = 6369.0$  hrs,  $SD = 2229.15$ ) did not differ  
324 in their total accumulated hours in all soccer activities,  $t(44) = 1.55$ ,  $p = .20$ ,  $d = 0.46$  ( $M_{\text{difference at}}$   
325  $19_{\text{yr}} = 2208.8$  hr, 95% CI [665.6, 5083.2]).

326 Comparisons of hours in soccer practice and other sports are shown in Figure 2. Based on  
327 log-transformed analyses in a 3-way ANOVA, there were no skill-related effects, only

328 significant effects for activity,  $F(1,44) = 232.62, p < .001, \eta_p^2 = .88$ , and age period,  $F(1, 32) =$   
 329  $16.22, p < .001, \eta_p^2 = .33$ . Players engaged in more soccer practice hours compared to other  
 330 sports ( $M_{\text{difference at 19 yr}} = 3238.5 \text{ hr}$ , 95% CI [2997.7, 3478.3]) and engaged in more activity in  
 331 adolescence compared to childhood ( $M_{\text{difference}} = 2502.9 \text{ hr}$ , 95% CI [2152.4, 2853.5]). The only  
 332 significant interaction was for age-period and activity,  $F(1, 44) = 7.42, p = .01, \eta_p^2 = .19$ .  
 333 Bonferroni comparisons indicated that players engaged in more soccer practice during  
 334 adolescence than during childhood ( $p < .001, d = 5.74, M_{\text{difference}} = 2168.3 \text{ hr}$ , 95% CI [1305.4,  
 335 3031.3]), but there were no differences across age periods for hours in other sports ( $p = .25, d =$   
 336  $1.17$ ).

### 337 Challenge ratings

338 The mean challenge rating data across the two skill groups and across childhood and  
 339 adolescence are displayed in Table 2. There were skill-group differences in challenge  
 340 perceptions for soccer play,  $F(1, 44) = 15.77, p = .01, \eta_p^2 = .26, M_{\text{difference}} = 1.14$ , 95% CI [.51,  
 341 1.76], but no significant differences for ratings of practice,  $F(1, 44) = 1.33, p = .26, \eta_p^2 = .03$ , or  
 342 ratings of competition,  $F(1,44) = 3.31, p = .07, \eta_p^2 = .07, M_{\text{difference}} = .94$ , 95% CI [-.04, 1.92]).  
 343 National players rated play as more challenging when compared to Varsity players, although  
 344 descriptive statistics showed play was generally rated as less challenging compared to practice or  
 345 competition. There were significant differences in perceived challenge across age periods for  
 346 competition,  $F(1, 44) = 71.63, p < .001, \eta_p^2 = .62, M_{\text{difference}} = .21$ , 95% CI [.14, .28] and practice,  
 347  $F(1, 44) = 15.77, p < .001, \eta_p^2 = .26, M_{\text{difference}} = .42$ , 95% CI [.24, .59], but not play,  $F(1, 44) =$   
 348  $1.45, p = .23, \eta_p^2 = .03$ . As expected, practice and competition were rated as more challenging in  
 349 adolescence compared to childhood.

350 The hours spent in developmental soccer activities that were rated as medium or high in  
351 perceived challenge were compared and showed significant differences between skill groups for  
352 practice,  $F(1,44) = 7.23, p = .01, \eta_p^2 = .13, M_{\text{difference}} = 874.2 \text{ hr}, 95\% \text{ CI } [220.2, 1528.2]$  and play,  
353  $F(1, 44) = 9.66, p < .01, \eta_p^2 = .17, M_{\text{difference}} = 280.4 \text{ hr}, 95\% \text{ CI } [98.9, 461.8]$ , but not competition  
354  $F(1, 44) = 3.65, p = .06, \eta_p^2 = .07, M_{\text{difference}} = 154.8 \text{ hr}, 95\% \text{ CI } [-9.2, 317.9]$ . As shown in Table  
355 2, National players spent more hours in challenging activities than Varsity players.

356 Both groups accumulated more hours in moderate to high challenge activities in  
357 adolescence compared to childhood for practice,  $F(1, 44) = 61.27, p < .001, \eta_p^2 = .57, M_{\text{difference}} =$   
358  $1307.2 \text{ hr}, 95\% \text{ CI } [971.3, 1643.3]$ , play,  $F(1, 44) = 10.05, p < .001, \eta_p^2 = .18, M_{\text{difference}} = 110.5$   
359  $\text{hr}, 95\% \text{ CI } [40.4, 180.6]$ , and competition,  $F(1, 44) = 19.08, p < .001, \eta_p^2 = .29, M_{\text{difference}} = 189.9$   
360  $\text{hr}, 95\% \text{ CI } [102.4, 277.3]$ . There were no significant effects involving age period, with the  
361 National players at both age periods, showing more hours in moderate/high challenge play than  
362 Varsity players.

### 363 **Player-player reliability**

364 For National players, the strength and similarity of estimates of current weekly hours in  
365 coach-led soccer practice activities were high ( $ICC = .85, PA = 90.75$ ), whereas for the Varsity  
366 players the strength of relationship between variables was moderate ( $ICC = .54$ ) but estimates  
367 were highly similar ( $PA = 88.75$ ). Based on inspection of within-group standard deviations,  
368 estimates of current hours per week in soccer practice were relatively low and indicative of  
369 consistency among players for both the National ( $M = 10.43 \text{ hr}, SD = 1.16$ ) and Varsity ( $M =$   
370  $10.66 \text{ hr}, SD = 1.45$ ) players. We did not have specific measures in place to determine reliability  
371 of the challenge ratings. However, in order to get a proxy of the stability of this measure, we  
372 looked at ICCs within individuals for each activity, across the various age groups. Although we

373 expected challenge perceptions to change over time, there was reason to think that this would be  
374 somewhat consistent on an individual level. The ICCs ranged from .55 for competition, to .61 for  
375 practice and .76 for competition, showing moderate to high level of agreement in ratings of  
376 challenge at an individual level (irrespective of time). We analysed these estimates at each age  
377 category, with the assumption being that if practice was deemed to be challenging by one player,  
378 then play and competition should also be deemed as challenging by this same player. We did not  
379 see the same high level of consistency as with the within-activity estimates across years,  
380 especially in the older age categories. The ICCs ranged from .17 to .56, with the lowest  
381 consistency at U17 and the highest at U7. Rather than evidence of poor reliability, this could be  
382 considered as evidence supporting the independence of the activities based upon our operational  
383 definitions.

### 384 **Discussion**

385 We provided a descriptive, cross sectional comparison of the developmental activities  
386 engaged in by National and Varsity women soccer players in Canada, allowing us to determine  
387 pathways to elite performance in reference to existing pathways of sport-skill expertise. Also, we  
388 adopted measures based upon the challenge point framework (Guadagnoli & Lee, 2004) to help  
389 determine which developmental soccer activities were most related to success at the elite levels  
390 of women's soccer. Overall, both the National and Varsity players engaged in higher volumes of  
391 soccer practice than play and competition across childhood and adolescence. Players spent more  
392 of their sport time in soccer practice activities from an early age than practice in other sports,  
393 even though they engaged in other sports throughout development. There were no significant  
394 group differences in the total number of hours in soccer activities. Although hours were not  
395 different between-groups for practice and competition, the National players accumulated more

396 hours in soccer play than the Varsity players. While these findings suggest that engagement in  
397 soccer play is an important discriminating variable in women's soccer (and hence consistent with  
398 the early engagement hypothesis), hours in play were relatively low in comparison to practice  
399 activity and data from male players. In this regard, the optimal challenge data may offer some  
400 insights into the differences across skill levels. Across development, National players engaged in  
401 significantly more hours in soccer practice and play activity rated as being moderate to high in  
402 challenge, relative to their current skill level, than Varsity players. These findings suggest that  
403 increased exposure to more optimally challenging, and thus higher quality, developmental  
404 activities are associated with optimal learning benefits, supporting predictions from the challenge  
405 point framework (Guadagnoli & Lee, 2004).

406 In contrast to previously reported data from elite male players (e.g., Hendry & Hodges,  
407 2018; Ward, Hodges, Starkes, & Williams, 2007), women National players started participation  
408 in structured soccer activities and specialized "academy" practice later than the Varsity players.  
409 However, these differences were not statistically significant, so it is difficult to make inferences  
410 about the potential benefits of beginning organized soccer training later rather than earlier in  
411 childhood. Furthermore, the Varsity players in this study were almost a decade younger than the  
412 National players. Thus, it is possible that in the ensuing decade the increased access to organized  
413 training academies may have created a situation where players engaged earlier. However, despite  
414 the likely enhanced opportunities for younger players, this was not reflected in total hours of  
415 soccer practice, suggesting that those older players may have had to be more pro-active in  
416 seeking out appropriate developmental soccer opportunities. The lack of coach-led practice  
417 opportunities may be partially responsible for the larger uptake of soccer play by the older (more  
418 elite) players, albeit no group by age period interaction was present. Both groups of athletes

419 reported engaging in co-recreational soccer for approximately 8 yrs, which is somewhat  
420 consistent with the findings of Gledhill and Harwood (2014). However, it did not discriminate  
421 between groups of highly skilled female soccer players. Gledhill and Harwood (2014) reported  
422 that elite players placed great value on their experiences of playing non-coach led, co-  
423 recreational soccer, yet we are unaware of any evidence that shows time in this activity during  
424 childhood discriminates across skill groups.

425 Over 90 % of the female players began participation in soccer practice activities from an  
426 early age (~5-6 yr). This is significant as the critical or sensitive periods of sport-skill  
427 development are thought to take place during childhood (Anderson, Magill & Thouvarecq, 2012;  
428 Côté et al., 2012). In relation to the early specialization and early engagement pathway, an early  
429 start age in domain specific activity is likely to provide sufficient practice for players to become  
430 and remain competitive, thus minimizing the risk of a player accruing practice deficits against  
431 those that had engaged in soccer activity earlier. However, no players participated exclusively in  
432 soccer. Neither did any player meet the criteria of specialization associated with increased  
433 incidence of injury, that is, engaging in more hours of single sport activity per week, than their  
434 current age, for a minimum 8 months of the year (Post et al. 2017). Inconsistent with both DMSP  
435 pathways is the result that multisport participation increased from childhood to adolescence. This  
436 increase in activity type may be related to more opportunities for sport participation during  
437 adolescence associated with high school related sports and a decreased need for parental support  
438 to engage in additional activities as children become more independent.

439 Overall, these data do not directly align with the specific pathways that have best  
440 described adult soccer success in male professional players (e.g., Ford et al., 2012, 2009; Hendry  
441 & Hodges, 2018), suggesting that these pathways may be culturally and contextually dependent

442 (Collins & MacNamara, 2017). However, in accord with previous research, the importance of  
443 domain specific activity in early childhood was highlighted (e.g., Ford et al., 2009; Hendry &  
444 Hodges, 2018; Sieghartsleitner et al., 2018). Both National and Varsity players engaged in more  
445 soccer practice compared to other sports from an early age. Where this differed from the early  
446 engagement pathway, was in respect to the relative contribution of *within-sport* diversity (e.g.,  
447 practice & play). Although the National players were still spending more time in play than the  
448 less elite, Varsity players, the relative amounts were small with female players engaging in less  
449 than 25% of their soccer activity time in unsupervised play-type activities compared to upwards  
450 of 75% in coach-led soccer practice.

451         The National and Varsity players did not differ in total accumulated soccer activity  
452 which was likely accounted for by the large variability in estimates within the groups. The lack  
453 of group discriminability was likely further exacerbated by the relative homogeneity of the  
454 groups with respect to skill (both were highly skilled) and primary engagement in coach-led  
455 activities (e.g., practice and competition) rather than self-directed soccer play. In comparison to  
456 the literature on men's soccer, women players had amassed a similar number of hours in soccer  
457 practice as elite males by age 16 yr (~ 3000 hr; Hendry & Hodges, 2018; Ford et al., 2012).  
458 However, the low volume of soccer play hours contrasts to the higher volume of soccer play  
459 engaged in during childhood by elite male players (Ford et al., 2012; 2009; Ford & Williams,  
460 2012; Hendry & Hodges, 2018). For example, academy-based, elite youth soccer players in  
461 Scotland had accumulated ~6 times more hours in play in comparison to the estimates provided  
462 by the current sample of National women players by age 16 yr (Male = ~3000 hr, Female = ~  
463 500 hr; Hendry & Hodges, 2018). Similarly, a sample of Canadian recreational, yet competitive,  
464 male players participated in more than double the amount of play compared to National women

465 players before the age of 16 yr (~1200 hr; Hendry, Crocker, Williams & Hodges, in review). It is  
466 unclear why play volumes were relatively low in these elite female soccer players compared to  
467 males. It may be that opportunities to engage in play activities in childhood, at least among this  
468 current sample, were low (e.g., playground soccer). Some researchers have remarked that  
469 negative socio-cultural expectations exist (or have existed) for females engaging in soccer play  
470 outside of formalized practice (Williams, 2007).

471         The lack of between-group discriminability in soccer activities highlights a potential  
472 limitation of measuring only developmental activity quantity (*cf.*, Ericsson et al., 1993).  
473 Therefore, we also collected measures of challenge to assess how activity quality might have  
474 contributed to expertise development across all activities. In general, mean challenge ratings  
475 were relatively low, which is either indicative of sub-optimal coaching for the female players or  
476 perhaps indicative of the precocity of the players even in childhood, where playing soccer was  
477 deemed as relatively “easy”. Incidentally, both National and Varsity players rated themselves as  
478 being within the top 10% of players within their respective teams throughout all stages of  
479 development (data not presented). Yet, accumulating more hours in moderate to high challenge  
480 soccer practice and play did successfully discriminate across the groups, with National players  
481 engaging in approximately 1,000 hrs more “challenging” soccer activity than Varsity players  
482 during development. Given the lack of difference in total accumulated soccer activities and the  
483 small difference in accumulated soccer play hours, the between group differences in hours in  
484 moderate to high challenge activities suggests that activity quality may be key in discriminating  
485 across these groups of highly skilled female players based on childhood activities. This finding is  
486 consistent with our hypotheses based upon the challenge point framework (Guadagnoli & Lee,  
487 2004).



488 Challenge ratings showed skill-group discriminability with respect to both activity type  
489 (e.g., play and practice) and age-period (e.g., childhood and adolescence). The fact that these  
490 challenge ratings discriminated across groups of highly skilled athletes provides initial support  
491 for the validity of these methods. Across both skill groups, competition was rated as the most  
492 challenging activity and play the least, although competition did not significantly distinguish  
493 across groups ( $p = .06$ ). In deliberate practice theory competition was viewed as “work”,  
494 contributing little to expertise attainment. Quality competition in childhood (as operationalised  
495 through challenge) might yet show to be an important developmental activity for later success in  
496 sport.

497 The study was limited in several ways. First, an *a priori* power analysis indicated that the  
498 study was underpowered. However, the relative uniqueness of the sample and scarcity of  
499 research into elite women’s soccer development provided rationale upon which to continue with  
500 the study, despite the participant numbers. Relatedly, at the risk of omitting some of the most  
501 decorated female soccer players over the last decade, we did not conduct outlier analyses on  
502 these data. This factor, allied to the differences in age and resultant access to soccer  
503 infrastructure may have contributed to the large variability (SD’s) within the National team  
504 group. It is worth noting though that the estimates were generally similar across the samples, at  
505 least for practice. We also know that the retrospective recall technique is prone to memory recall  
506 error and bias, which may also have contributed to within and between group differences across  
507 activities (e.g., Hodges, Huys, & Starkes, 2007; Hopwood, 2015). Although we were unable to  
508 collect data from parents and coaches to further test for reliability, mostly because of the varied  
509 backgrounds and locations of the players, we were able to show within group consistencies for  
510 estimates of current practice hours.

511           The current study adds to the literature in two ways. First, this is one of the first studies to  
512 describe and detail the developmental activities engaged in by world-class female soccer players.  
513 Second, attempts were made to measure the quality of developmental activities, based on the  
514 interacting conditions thought to elicit optimal challenge (Guadagnoli & Lee, 2004). The fact  
515 that challenge ratings for play and hours in moderate to highly challenging practice and play  
516 distinguished between skill-groups points to the validity and potential usefulness of this in  
517 measuring the developmental practice activities that contribute to elite development in sport.  
518 However, more work is required to validate the challenge ratings used. Although each player  
519 provided challenge ratings for multiple activities across all age categories, they only provided a  
520 single-item rating. Consequently, some validation of this single item measure is needed, perhaps  
521 through self-report and/or psychophysiological measurements in situ. We also acknowledge that  
522 the specific nature of challenge (e.g., cognitive, perceptual, motor, physiological) needs to be  
523 identified. In future, researchers could test the interdependence of challenge types and/or the  
524 extent to which these components individually or collectively interact with specific  
525 developmental activities.

526           In summary, we have presented data showing that world-class (National) and sub-elite  
527 (Varsity) female soccer players in Canada show developmental profiles which, similar to elite  
528 male players, highlight the importance of domain specificity, rather than sporting diversity, in  
529 developing soccer expertise. National team players participated in greater amounts (~500 more  
530 hours) and more challenging soccer play in childhood than less elite, Varsity players, although  
531 notably these overall amounts of play were low when compared with data reported for male  
532 players. Although they did not differ in total amounts of practice, they did differ in the hours  
533 spent in soccer practice deemed to be of moderate to high challenge. The differences across skill-

534 groups with respect to challenge and hours in challenging activities paves the way for future  
535 research focusing on how best to measure and evaluate current domain specific activities using  
536 the challenge-point framework. Although the current data point towards player development  
537 profiles consistent with early specialization and somewhat, early (majority) engagement, the  
538 relatively low amounts of play versus structured practice from an early age and the increasing  
539 involvement in a variety of sports as the athletes developed, is not consistent with either  
540 pathway. There is therefore a need to validate and extend this research across different samples  
541 of adult female soccer athletes as well as current, female youth players. Prospective research  
542 with youth players at the elite levels should enable stronger conclusions about the pathways that  
543 are most conducive to success in soccer.

544

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- 652



653

**Footnote**

654 1. There were no group differences when comparing the National (n = 13) and Varsity (n = 15)  
655 players who had reported individual practice hours,  $F(1,26) = 1.49$ ,  $p = .23$ ,  $\eta_p^2 = .05$ ,  
656  $M_{\text{difference}} = 271.84$  hr; 95% CI [-.73, 186.49 hr]. These hours did not differ across age period  
657 ( $F < 1$ ), nor was there a Group X Age period interaction ( $F < 1$ ). We also combined individual  
658 practice hours with play to give an estimate of non-coach led soccer activities (see Hendry et al.,  
659 2018). The combined data mirrored that shown from just analyzing play data alone. That is, there  
660 were significant group differences,  $F(1,44) = 5.13$ ,  $p = .03$ ,  $\eta_p^2 = .11$ ,  $M_{\text{difference}} = 513.42$  hr;  
661 95% CI [31.80, 994.68 hr] but no main effect of age period, nor Group X Age Period interaction,  
662 ( $F_s < 1$ ).

663

664 **Table 1. Mean ages (SD) for soccer milestones for National and Varsity women soccer**  
 665 **players and number of other sports participated in childhood (5-12 yr) and adolescence**  
 666 **(13-19 yr)**

	All	National ( <i>n</i> = 21)	Varsity ( <i>n</i> =24)
<b>Soccer milestones (yr)</b>			
672 Start age in soccer activities	4.95 (1.64)	5.43 (2.06)	4.50 (.96)
673 Start age in soccer practice	5.65 (1.85)	6.28 (2.19)	5.05 (1.21)
674 Start age in soccer academy	14.03 (3.90)	15.42 (2.98)	12.14 (4.31)
675 Age in National-youth team <sup>‡</sup>	14.85 (3.29)	15.65 (1.53)	13.50 (4.89)
676 Start co-rec. soccer <sup>‡</sup>	7.37 (4.42)	8.00 (5.52)	6.80 (3.19)
677 End co-rec. participation <sup>‡</sup>	10.69 (4.9)	11.51 (5.92)	9.73 (3.75)
<b># Other sports</b>			
679 Childhood	4 (2.5)	3 (2.1)	5 (2.4)
680 Adolescence	4 (2.5)	4 (2.6)	5 (2.3)

682 <sup>‡</sup>For this analysis, National (*n* = 18), Varsity (*n* = 10). <sup>#</sup>For this analysis, National (*n* = 15),  
 683 Varsity (*n* = 14).

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688 **Table 2. Means (and SDs) for hours in soccer activities (competition, practice, play), for challenge ratings and for hours in**  
 689 **moderate to high challenge soccer activities, during childhood and adolescence for the National and Varsity women athletes.**

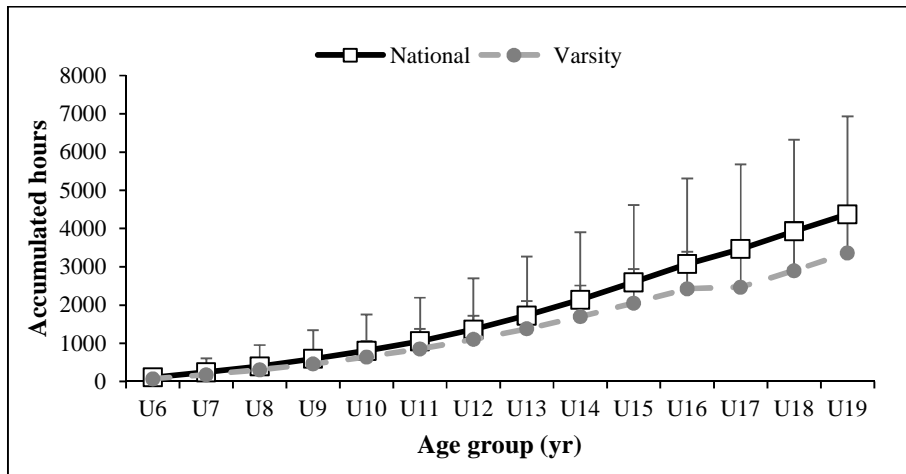
	National		Varsity		
	Childhood	Adolescence	Childhood	Adolescence	
694	<b>Hours in soccer activities</b>				
695	Practice	1727.1 (1438.2)	4372.7 (2563.8)	1382.6 (724.5)	3365.4 (1006.9)
696	Play	417.1 (348.0)	634.5 (459.6)	76.1 (56.0)	115.4 (105.0)
697	Competition	418.7 (323.3)	792.6 (589.7)	401.0 (207.5)	1028.5 (321.4)
698	<b>Challenge ratings (0-4)</b>				
699	Practice	1.76 (.61)	2.38 (.61)	1.60 (.83)	2.24 (.74)
700	Play	.88 (.81)	1.10 (.98)	.46 (.70)	.69 (.90)
701	Competition	2.15 (.78)	3.32 (.73)	1.85 (.88)	2.93 (2.72)
702	<b>Hours in moderate to high challenge soccer activity</b>				
703	Practice	1309.63 (897.94)	2931.10 (1178.56)	749.65 (613.84)	1742.73 (1082.35)
704	Play	243.09 (149.98)	198.36 (325.71)	14.07 (35.19)	17.05 (42.07)
705	Competition	283.41 (324.50)	555.73 (459.69)	210.99 (195.09)	318.46 (284.99)
706					

**Figure Headings**

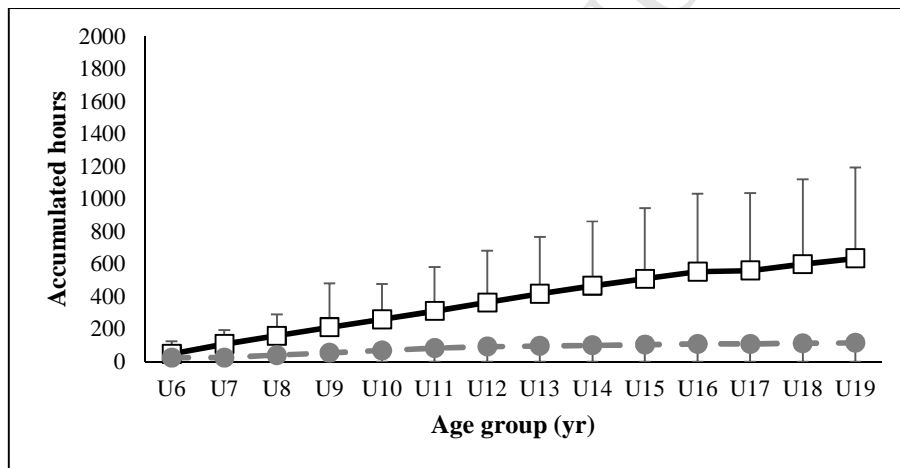
Figure 1. Mean (and SD bars) for accumulated hours in soccer practice (a), play (b) and competition (c) by National and Varsity soccer players from the under 6 yr age-group (U6) to under 19 yr (U19). Please note that Figure 1a has a different scale with a maximum value of 8000 hr compared to play and competition where this is 2000 hours.

Figure 2. Mean accumulated hours (and SD bars) in soccer practice and practice in other sports as a function of age period (childhood or adolescence) and skill (National, Varsity).

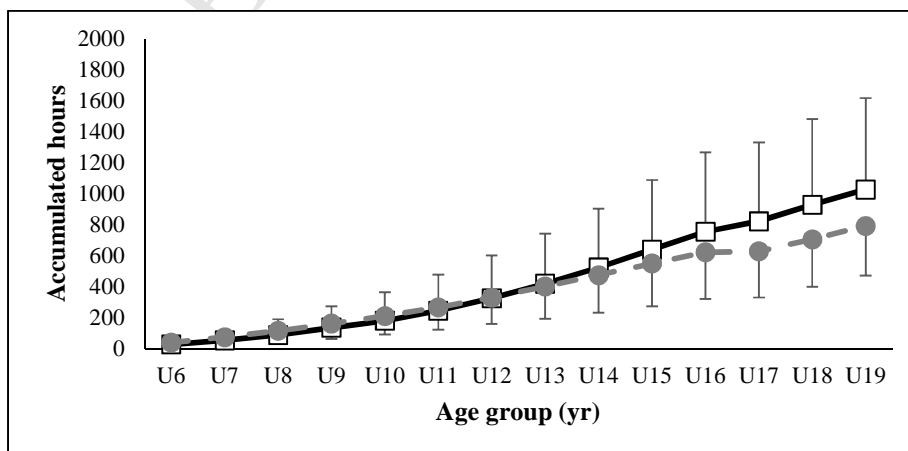
a)

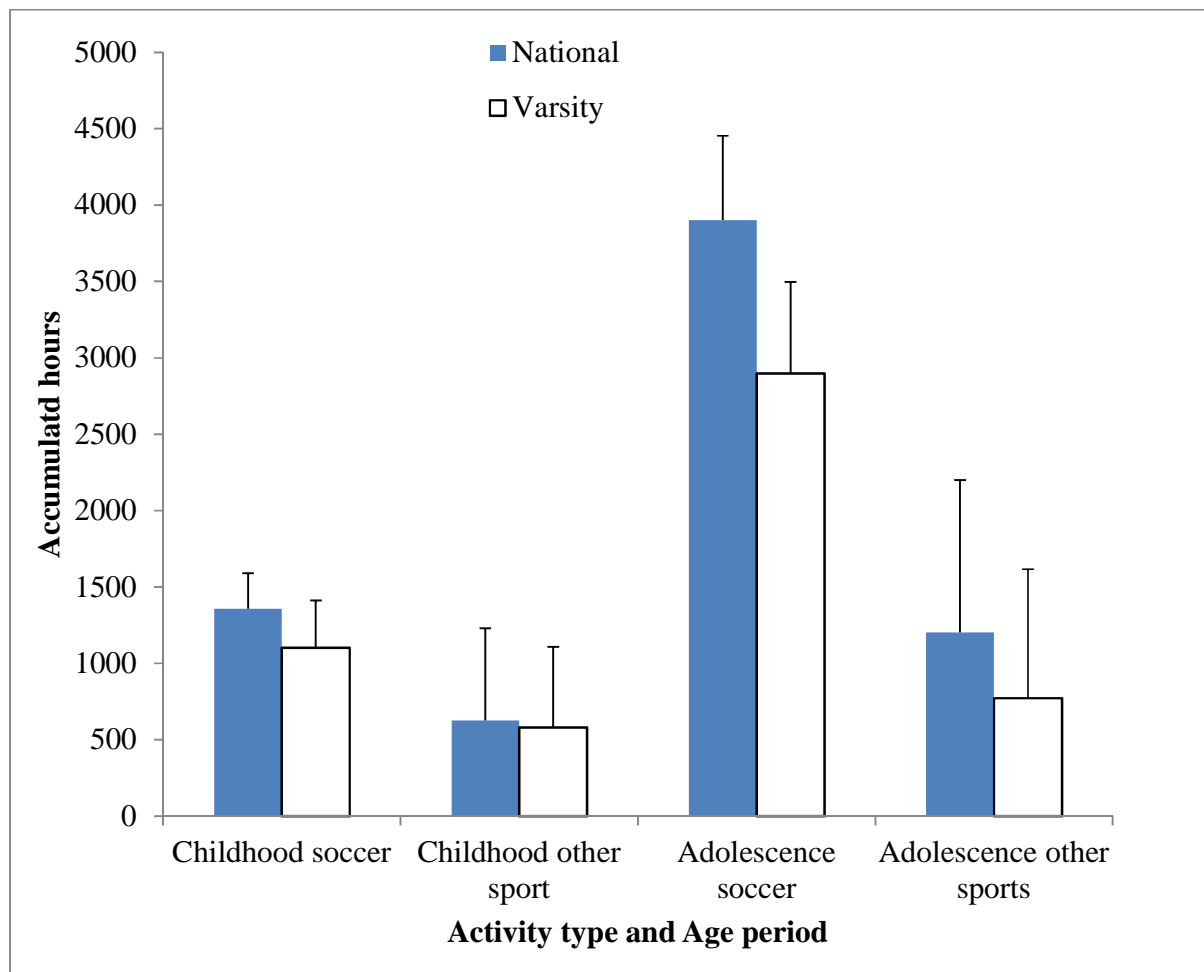


b)



c)





**Highlights**

- National & Varsity women soccer players competing at the highest levels took part
- Elite groups were distinguished by childhood self-directed play not practice
- Relative to practice hours and to men, hours in play were low (<25% in childhood)
- National players engaged in more hours of soccer activities rated challenging
- Like male players, women started young and showed majority engagement in soccer