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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.

1. Introduction

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

There has been some qualitative research directed at uncovering the developmental experiences of elite National female soccer players in England (Gledhill & Harwood, 2014). One developmental activity viewed by the players as beneficial to later success was early competition experience involving male players at ~10–12 yr. Competitive, co-recreation opportunities tended to cease from 12 to 14 yr, at which point elite players participated in organized female-only teams. However, because this study had a broad focus on a variety of developmental experiences, such as family influences, limited information was provided on developmental activities. Moreover, there is reason to suspect that the developmental activities and experiences of female soccer players in England would be different to that of North American players. In England, participation opportunities for organized soccer

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among girls is relatively new, whereas female participation in youth soccer has been a popular, high participation sport for many years in North America (FIFA, 2014; The Football Association, 2018).

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

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

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

In many respects, the challenge point framework is analogous to some of the components of deliberate practice theory, in which expertise is achieved by continuously progressing practice to stretch the limits of current capacities. One of the major differences between deliberate practice and play is based upon the intention of the participant. For play, the primary intention is to experience fun and enjoyment, whereas for practice, the primary intention is performance improvement. However, skill acquisition can emerge as a by-product from engagement in play, especially in the earlier stages of participation, irrespective of any specific intention. For example, in soccer, positive associations have been demonstrated between soccer play amounts in childhood and later soccer expertise (Ford et al., 2012, 2009; Ford & Williams, 2012; Hornig et al., 2016). Therefore, it may be that the difficulty of the task relative to the learner, whether in play, practice or competition, is as, or more, important than the specific intention behind engagement in the behaviour. An assessment of the individualized degree of challenge associated with each developmental activity at different milestones would provide one measure of the quality of the activity (regardless of the type) and may relate to later expertise. Although it is likely that players with intentions to improve will more likely seek out high challenge situations, high challenge is not always a characteristic of practice. Similarly, play activities are not necessarily less challenging than those encountered in practice.

Some researchers have proposed that experience in competition is a key part of the development of expertise in sport (Abernethy, Farrow, & Berry, 2003; Singer & Janelle, 1999). In youth development in soccer, competition is often viewed as an extension of practice in which the experience of playing against various opponents in varied environments benefits skill acquisition (Cook, Crust, Littlewood, Nesti, & Allen-Collinson, 2014; Ford, 2016). In contrast, competition in deliberate practice theory is viewed as "work", with the assumption that it is motivated by external rewards and lacks opportunities for experimentation and feedback (Ericsson, Krampe, & Tesch-Römer C, 1993). In support of this view, time spent in competition is not usually a discriminatory variable in youth soccer domains (e.g., Ford et al., 2012, 2009; Ford & Williams, 2012). This finding is likely a function of the fact that leagues or organizations often externally control the number and duration of games such that they are similar for all groups and skill levels. However, it may be that it is the degree of relative challenge experienced during competition that distinguishes across skill groups. If the challenging nature of the activity is a good measure of its quality, then hours spent in soccer activities that are judged to be challenging, (i.e., activities that are moderate to highly demanding relative to the athlete's skill), will differentiate across skill groups and potentially provide greater discriminability than assessments based upon accumulated soccer activity hours alone.

The primary aim of this study was to determine the hours accumulated in developmental activities in soccer and other sports during childhood (5–12 yr) and adolescence (12–18 yr) and compare across National and Varsity women soccer players in Canada. A secondary aim was to determine whether greater discriminability could be achieved by comparing hours in these activities based on moderate to high perceived task difficulty (i.e., optimally challenging). In accordance with the development pathways engaged in by elite male soccer players, we

expected that National female players would participate in higher volumes of soccer practice and play compared to female Varsity athletes. However, we were uncertain as to whether developmental profiles would primarily be characterised by an early specialisation or engagement profile (as seen in men's soccer) or by a more diversified sport involvement. We anticipated that the more elite players (National) would have engaged in more optimally challenging (i.e., moderate to high challenge) developmental activities during childhood and adolescence than the Varsity players.

2. Methods

2.1. Participants

Participants were female, soccer players ($N = 45$), consisting of 21 National and 24 Varsity level players in Canada. National players (M age = 28.26, SD = 3.95 yr) were participating at the international level, ranked within the top 10 national teams in the world (and all of whom had competed in Olympic competition). Because of the exhaustive nature of our sample (i.e., our current sample was almost a complete representation of the Canadian National women's team), we were limited by the number of athletes that could be recruited. This naturally causes issue for power and as such, some caution is needed in interpretation. Based on an a priori power analysis (G*Power; Erdfelder, Faul, & Buchner, 1996), we would have needed n = 33 athletes in each sample (based on 1-ß = 0.80; 2 × 2 mixed-design ANOVA, with Bonferroni adjusted alpha of .017 and the smallest effect size based on elite male soccer activity volumes; $\eta_p^2 = 0.04$/Cohen's f = 0.20; Hendry & Hodges, 2018). Because of the highly elite nature of the sample and the scarcity of research on women's soccer, we felt that continuation with the study was merited. In an effort to keep some homogeneity in variance between samples, our Varsity group was based on a similar sample size.

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

2.2. Procedures and measures

Contact was initially made with representatives from the National and Varsity teams via email correspondence before players were approached. After a briefing on the purpose of the study and the provision of informed consent, participants completed a series of questionnaires to provide information pertaining to soccer milestones, developmental soccer activities and developmental activity challenge. These were completed in small groups, in rooms supervised by members of the research team who provided clarification of all operational definitions including soccer activity type and optimal challenge. The questionnaires took approximately 45 min to complete.

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

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

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

Perceptions of challenge: Alongside each weekly soccer activity estimate, participants recorded the recalled degree of challenge associated with each activity relative to their own skill level at that time-point. The research team explained that challenge related to the balance between their current skill level versus the difficulty/challenge associated with the activity and playing against others in that activity at that time. Optimal challenge was operationally defined as moderate to high-challenge and to represent activities that "continually test your abilities, that are demanding and/or stimulating." Participants were asked to provide ratings of the challenge (i.e., difficulty of the activity in relation to their own skill) for each soccer activity, at every age group, using a 5-point scale (0 = Not at all challenging/easy, 1 = Some/low challenge, 2 = Moderate challenge, 3 = High challenge, 4 = Too much challenge/extremely challenging).

2.3. Statistical analyses

The data were checked for normality using the Shapiro-Wilk test. When the magnitude of skewness was less than 1, indicating only a tendency towards positive skewness (Bulmer, 1979), and there were no significant group differences in homogeneity of variance, we used parametric methods (Glass, Peckham, & Sanders, 1972; Pallant, 2007). In cases where assumptions were not met (i.e., for estimates of practice hours in soccer and multisport activities), we performed a $\log_{10}$ transformation to normalize data before analysis (Tabachnick & Fidell, 2013). Confidence intervals (95%) around the mean difference are reported for all pairwise comparisons. Since ~38% of athletes did not engage in individual practice from U6 to U11 yr and only ~20%

engaged in individual practice from U12 − U16 yr, we combined individual and coach-led practice estimates. Individual and team practice have been combined in the past to reflect deliberate practice activities (e.g., Helsen, Starkes, & Hodges, 1998; Ford et al., 2009). However, we conducted separate analyses on these data, as noted in Footnote 1, to show that the groups did not differ with respect to individual practice amounts and that changing the analysis to consider individual practice as a self-led "play-type" activity, would not have changed the overall pattern of results.[1]

Developmental activity milestones: We compared across the skill groups (National, Varsity), for five major soccer milestones, using independent t-tests with Bonferroni adjustments ($p = .05/5 = 0.01$). Comparisons were made for start age in structured and unstructured soccer activities, age of entry into an elite development practice setting (i.e., academy) and age of national youth team selection. Based on start and end age in co-recreation organized soccer, we calculated duration (in yr) of co-rec participation.

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

Challenge ratings: We calculated mean challenge ratings by aggregating the mean individual challenge score for each activity across each year for childhood and adolescence age periods. Comparisons were made across practice, play and competition using three separate 2 Skill x 2 Age period ANOVAs. Using the challenge ratings, we calculated accumulated hours in "optimally challenging" activities, defined as moderate to high challenge soccer activities (ratings of 2 and 3) for each activity and compared these in similar 2-way ANOVAs (with Bonferroni adjusted p values, $0.05/3 = 0.017$).

Player-player reliability: Two separate sections of the questionnaire were compared, where we had asked for estimates of hr/week in current coach-led practice. In the first section, players provided an overall estimate of hr/week in soccer coach-led practice, whereas in the second, players provided separate entries for number of sessions/week and hours/session. The strength and similarity of these weekly activity estimates were assessed with intra-class correlation (*ICC*) using Cronbach's alpha and percent agreement *(PA)* scores respectively. This combination of analyses, has been recommended for the assessment of validity and reliability of activity estimates (Atkinson & Nevill, 1998; Hopwood, 2015). ICC's were also used to assess the within-person reliability of challenge ratings for each activity across the developmental period (U6−U19 yr), with the assumption that although these would change across time, they should remain relatively consistent on an individual level. We also ran ICCs on each activity (practice, play and competition) for each year, assuming that there would be a degree of within-person consistency across the activities within each developmental age-group. Of course, because these measures of reliability were not assessing the same things twice, these only give an approximate insight into consistency in ratings across individuals.

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

3. Results

3.1. Developmental activity milestones

The ages at which the National and Varsity players reached various milestones in soccer are presented in Table 1. The players started in soccer during early childhood (~5 yr) but start age did not differ across groups. The age of participation in structured soccer practice, $t(43) = 2.43$, $p = .02$, $d = 0.78$, $M_{difference} = 1.23$ yr, 95% CI [0.02, 2.23] and start age in an Academy, $t(44) = 2.58$, $p = .02$, $d = 0.89$, $M_{difference} = 3.28$ yr, 95% CI [1.02, 5.54], occurred at a later age for the National when compared to the Varsity group, but these differences were not statistically significant based on Bonferroni corrected p values. The number of National ($n = 15$) and Varsity players ($n = 14$) that had played co-recreational soccer as a child and the average number of years played did not differ, $t(27) = 1.21$, $p = .23$, $d = 0.04$, $M_{difference} = 0.58$ yr, 95% CI [-1.16, 4.72]. There were no differences in terms of start age in a youth international team, $t(27) = 1.69$, $p = .10$, $d = 0.04$, $M_{difference} = 2.14$ yr, 95% CI [-4.75, 0.46], albeit only $n = 10$ Varsity players attained this level in comparison to $n = 18$ of the National players.

The National players participated in fewer sports than the Varsity players, $F(1,44) = 7.43$, $p = .01$, $\eta_p^2 = 0.14$, $M_{difference} = 2$ sports, 95% CI [0.64, 3.42] and this did not differ across age categories, $F(1,44) = 1.05$, $p = .31$, $\eta_p^2 = 0.02$ (see Table 1).

3.2. Developmental activity hours

The mean accumulated hours in soccer activities across the developmental timespan are presented in Fig. 1a, b and c (5–19 yr, that is, U6−U19 yr age-groups). RM ANOVAs comparing across the childhood and adolescence periods only showed skill-group differences in accumulated hours in soccer play, $F(1, 44) = 13.62$, $p = .01$, $\eta_p^2 = 0.26$, but not in practice or competition ($Fs < 1$). The National players accumulated more hours in soccer play compared to Varsity players, $M_{difference\ at\ 19\ years} = 519.3$ h, 95% CI [220.9, 817.6]. There were significant age period differences for accumulated hours in soccer practice, $F(1, 44) = 23.09$, $p = < .001$, $\eta_p^2 = 0.37$, $M_{difference} = 1045.8$ h, 95% CI [768.5, 1323.2] and competition, $F(1, 44) = 38.09$, $p = < .001$, $\eta_p^2 = 0.49$, $M_{difference} = 204.9$ h, 95% CI [132.7, 276.4], but not soccer play ($F < 1$). More hours were accumulated in adolescent practice and competition than in childhood. There were no significant interactions involving skill groups. For reference, by 19 years of age, the National ($M = 8361.6$ h, $SD = 5016.96$) and Varsity players ($M = 6369.0$ h, $SD = 2229.15$) did not differ in their total accumulated hours in all soccer activities, $t(44) = 1.55$, $p = .20$, $d = 0.46$ ($M_{difference\ at\ 19\ yr} = 2208.8$ h, 95% CI [665.6, 5083.2]).

Comparisons of hours in soccer practice and other sports are shown in Fig. 2. Based on log-transformed analyses in a 3-way ANOVA, there were no skill-related effects, only significant effects for activity, $F(1,44) = 232.62$, $p < .001$, $\eta_p^2 = 0.88$, and age period, $F(1, 32) = 16.22$, $p < .001$, $\eta_p^2 = 0.33$. Players engaged in more soccer practice hours compared to other sports ($M_{difference\ at\ 19\ yr} = 3238.5$ h, 95% CI [2997.7, 3478.3]) and engaged in more activity in adolescence compared to childhood ($M_{difference} = 2502.9$ h, 95% CI [2152.4,

[1] There were no group differences when comparing the National (n = 13) and Varsity (n = 15) players who had reported individual practice hours, $F(1,26) = 1.49$, $p = .23$, $\eta_p^2 = 0.05$, $Mdifference = 271.84$ h; 95% CI [-0.73, 186.49 h]. These hours did not differ across age period ($F < 1$), nor was there a Group X Age period interaction ($F < 1$). We also combined individual practice hours with play to give an estimate of non-coach led soccer activities (see Hendry et al., 2018). The combined data mirrored that shown from just analyzing play data alone. That is, there were significant group differences, $F(1,44) = 5.13$, $p = .03$, $\eta_p^2 = 0.11$, $Mdifference = 513.42$ h; 95% CI [31.80, 994.68 h] but no main effect of age period, nor Group X Age Period interaction, (Fs < 1).

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

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

[a] For this analysis, National (n = 18), Varsity (n = 10).
[b] For this analysis, National (n = 15), Varsity (n = 14).

2853.5]). The only significant interaction was for age-period and activity, $F(1, 44) = 7.42$, $p = .01$, $\eta_p^2 = 0.19$. Bonferroni comparisons indicated that players engaged in more soccer practice during adolescence than during childhood ($p < .001$, $d = 5.74$, $M_{difference} = 2168.3$ h, 95% CI [1305.4, 3031.3]), but there were no differences across age periods for hours in other sports ($p = .25$, $d = 1.17$).

3.3. Challenge ratings

The mean challenge rating data across the two skill groups and across childhood and adolescence are displayed in Table 2. There were skill-group differences in challenge perceptions for soccer play, $F(1, 44) = 15.77$, $p = .01$, $\eta_p^2 = 0.26$, $M_{difference} = 1.14$, 95% CI [0.51, 1.76], but no significant differences for ratings of practice, $F(1, 44) = 1.33$, $p = .26$, $\eta_p^2 = 0.03$, or ratings of competition, $F(1,44) = 3.31$, $p = .07$, $\eta_p^2 = 0.07$, $M_{difference} = 0.94$, 95% CI [-0.04, 1.92]). National players rated play as more challenging when compared to Varsity players, although descriptive statistics showed play was generally rated as less challenging compared to practice or competition. There were significant differences in perceived challenge across age periods for competition, $F(1, 44) = 71.63$, $p < .001$, $\eta_p^2 = 0.62$, $M_{difference} = 0.21$, 95% CI [0.14, 0.28] and practice, $F(1, 44) = 15.77$, $p = < .001$, $\eta_p^2 = 0.26$, $M_{difference} = 0.42$, 95% CI [0.24, 0.59], but not play, $F(1, 44) = 1.45$, $p = .23$, $\eta_p^2 = 0.03$. As expected, practice and competition were rated as more challenging in adolescence compared to childhood.

The hours spent in developmental soccer activities that were rated as medium or high in perceived challenge were compared and showed significant differences between skill groups for practice, $F(1,44) = 7.23$, $p = .01$, $\eta_p^2 = 0.13$, $M_{difference} = 874.2$ h, 95% CI [220.2, 1528.2] and play, $F(1, 44) = 9.66$, $p < .01$, $\eta_p^2 = 0.17$, $M_{difference} = 280.4$ h, 95% CI [98.9, 461.8], but not competition $F(1, 44) = 3.65$, $p = .06$, $\eta_p^2 = 0.07$, $M_{difference} = 154.8$ h, 95% CI [-9.2, 317.9]. As shown in Table 2, National players spent more hours in challenging activities than Varsity players.

Both groups accumulated more hours in moderate to high challenge activities in adolescence compared to childhood for practice, $F(1, 44) = 61.27$, $p < .001$, $\eta_p^2 = 0.57$, $M_{difference} = 1307.2$ h, 95% CI [971.3, 1643.3], play, $F(1, 44) = 10.05$, $p < .001$, $\eta_p^2 = 0.18$, $M_{difference} = 110.5$ h, 95% CI [40.4, 180.6], and competition, $F(1, 44) = 19.08$, $p < .001$, $\eta_p^2 = 0.29$, $M_{difference} = 189.9$ h, 95% CI [102.4, 277.3]. There were no significant interaction effects involving age period, with the National players at both age periods, showing more hours in moderate/high challenge play than Varsity players.

3.4. Player-player reliability

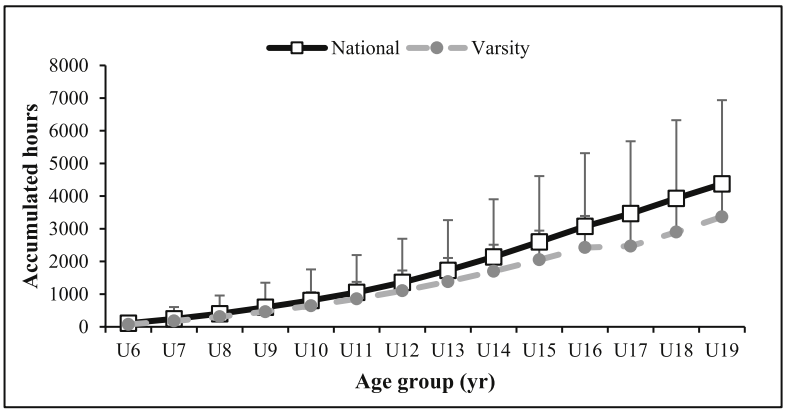
For National players, the strength and similarity of estimates of current weekly hours in coach-led soccer practice activities were high ($ICC = 0.85$, $PA = 90.75$), whereas for the Varsity players the strength of relationship between variables was moderate ($ICC = 0.54$) but estimates were highly similar ($PA = 88.75$). Based on inspection of within-group standard deviations, estimates of current hours per week in soccer practice were relatively low and indicative of consistency among players for both the National ($M = 10.43$ h, $SD = 1.16$) and Varsity ($M = 10.66$ h, $SD = 1.45$) players. We did not have specific measures in place to determine reliability of the challenge ratings. However, in order to get a proxy of the stability of this measure, we looked at ICCs within individuals for each activity, across the various age groups. Although we expected challenge perceptions to change over time, there was reason to think that this would be somewhat consistent on an individual level. The ICCs ranged from 0.55 for competition, to 0.61 for practice and .76 for competition, showing moderate to high level of agreement in ratings of challenge at an individual level (irrespective of time). We analysed these estimates at each age category, with the assumption being that if practice was deemed to be challenging by one player, then play and competition should also be deemed as challenging by this same player. We did not see the same high level of consistency as with the within-activity estimates across years, especially in the older age categories. The ICCs ranged from 0.17 to 0.56, with the lowest consistency at U17 and the highest at U7. Rather than evidence of poor reliability, this could be considered as evidence supporting the independence of the activities based upon our operational definitions.

4. Discussion

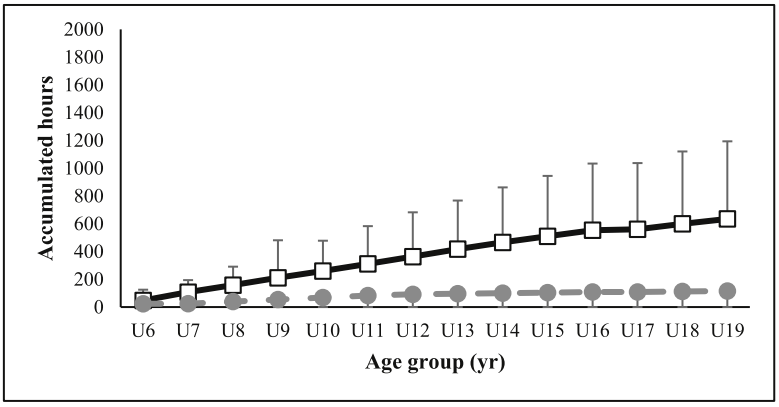
We provided a descriptive, cross sectional comparison of the developmental activities engaged in by National and Varsity women soccer players in Canada, allowing us to determine pathways to elite performance in reference to existing pathways of sport-skill expertise. Also, we adopted measures based upon the challenge point framework (Guadagnoli & Lee, 2004) to help determine which developmental soccer activities were most related to success at the elite levels of women's soccer. Overall, both the National and Varsity players engaged in higher volumes of soccer practice than play and competition across childhood and adolescence. Players spent more of their sport time in soccer practice activities from an early age than practice in other sports, even though they engaged in other sports throughout development. There were no significant group differences in the total number of hours in soccer activities. Although hours were not different between-groups for practice and competition, the National players accumulated more hours in soccer play than the Varsity players. While these findings suggest that engagement in soccer play is an important discriminating variable in women's soccer (and hence consistent with the early engagement hypothesis), hours in play were relatively low in comparison to practice activity and data from male players. In this regard, the optimal challenge data may offer some insights into the differences across skill levels. Across development, National players engaged in significantly more hours in soccer practice and play activity rated as being moderate to high in challenge, relative to their current skill level, than Varsity players. These findings suggest that increased exposure to more optimally challenging, and thus higher quality, developmental activities are associated with optimal learning benefits, supporting predictions from the challenge point framework (Guadagnoli & Lee, 2004).

In contrast to previously reported data from elite male players (e.g., Hendry & Hodges, 2018; Ward, Hodges, Starkes, & Williams, 2007), women National players started participation in structured soccer activities and specialized "academy" practice later than the Varsity players. However, these differences were not statistically significant, so it is difficult to make inferences about the potential benefits of beginning organized soccer training later rather than earlier in childhood.

a)



b)



c)

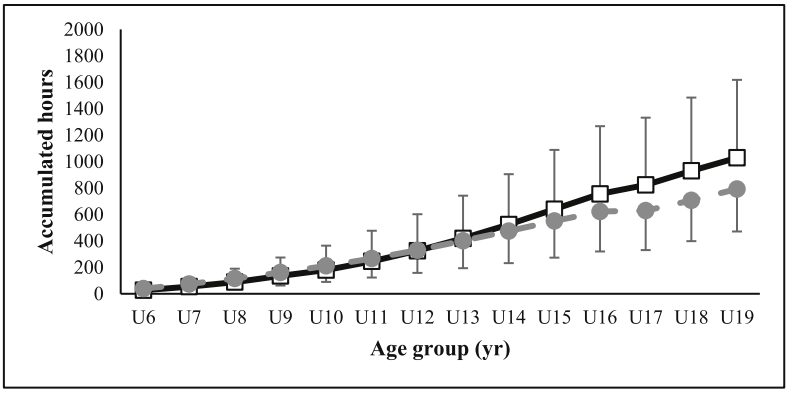


Fig. 1. Mean (and SD bars) for accumulated hours in soccer practice (a), play (b) and competition (c) by National and Varsity soccer players from the under 6 yr age-group (U6) to under 19 yr (U19). Please note that Fig. 1a has a different scale with a maximum value of 8000 h compared to play and competition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

Furthermore, the Varsity players in this study were almost a decade younger than the National players. Thus, it is possible that in the ensuing decade the increased access to organized training academies may have created a situation where players engaged earlier. However, despite the likely enhanced opportunities for younger players, this was not reflected in total hours of soccer practice, suggesting that those older players may have had to be more pro-active in seeking out appropriate developmental soccer opportunities. The lack of coach-led practice opportunities may be partially responsible for the larger uptake of soccer play by the older (more elite) players, albeit no group by age period interaction was present. Both groups of athletes reported engaging in co-recreational soccer for approximately 8 yrs, which is somewhat consistent with the findings of Gledhill and Harwood (2014). However, it did not discriminate between groups of highly skilled female soccer players. Gledhill and Harwood (2014) reported that elite players placed great value on their experiences of playing non-coach led, co-recreational soccer, yet we are unaware of any evidence that shows time in this activity during childhood discriminates across skill groups.

Over 90% of the female players began participation in soccer practice activities from an early age (~5–6 yr). This is significant as the critical or sensitive periods of sport-skill development are thought to

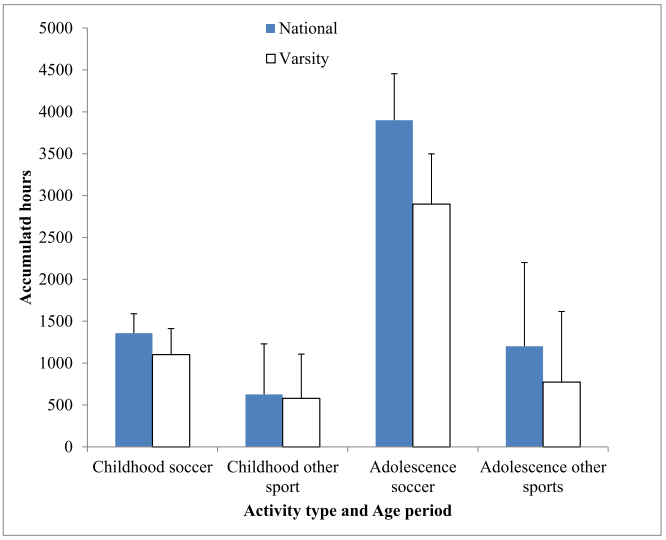


Fig. 2. Mean accumulated hours (and SD bars) in soccer practice and practice in other sports as a function of age period (childhood or adolescence) and skill (National, Varsity).

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

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

take place during childhood (Anderson, Magill, & Thouvarecq, 2012; Côté et al., 2012). In relation to the early specialization and early engagement pathway, an early start age in domain specific activity is likely to provide sufficient practice for players to become and remain competitive, thus minimizing the risk of a player accruing practice deficits against those that had engaged in soccer activity earlier. However, no players participated exclusively in soccer. Neither did any player meet the criteria of specialization associated with increased incidence of injury, that is, engaging in more hours of single sport activity per week, than their current age, for a minimum 8 months of the year (Post et al., 2017). Inconsistent with both DMSP pathways is the result that multisport participation increased from childhood to adolescence. This increase in activity type may be related to more opportunities for sport participation during adolescence associated with high school related sports and a decreased need for parental support to engage in additional activities as children become more independent.

Overall, these data do not directly align with the specific pathways that have best described adult soccer success in male professional players (e.g., Ford et al., 2009, 2012; Hendry & Hodges, 2018), suggesting that these pathways may be culturally and contextually dependent (Collins & MacNamara, 2017). However, in accord with previous research, the importance of domain specific activity in early childhood was highlighted (e.g., Ford et al., 2009; Hendry & Hodges, 2018; Sieghartsleitner et al., 2018). Both National and Varsity players engaged in more soccer practice compared to other sports from an early age. Where this differed from the early engagement pathway, was in respect to the relative contribution of *within-sport* diversity (e.g., practice & play). Although the National players were still spending more time in play than the less elite, Varsity players, the relative amounts were small with female players engaging in less than 25% of their soccer activity time in unsupervised play-type activities compared to upwards of 75% in coach-led soccer practice.

The National and Varsity players did not differ in total accumulated soccer activity which was likely accounted for by the large variability in estimates within the groups. The lack of group discriminability was likely further exacerbated by the relative homogeneity of the groups with respect to skill (both were highly skilled) and primary engagement in coach-led activities (e.g., practice and competition) rather than self-directed soccer play. In comparison to the literature on men's soccer, women players had amassed a similar number of hours in soccer practice as elite males by age 16 yr (~3000 h; Hendry & Hodges, 2018; Ford et al., 2012). However, the low volume of soccer play hours contrasts to the higher volume of soccer play engaged in during childhood by elite male players (Ford et al., 2009, 2012; Ford & Williams, 2012; Hendry & Hodges, 2018). For example, academy-based, elite youth soccer players in Scotland had accumulated ~6 times more hours in play in comparison to the estimates provided by the current sample of National women players by age 16 yr (Male = ~3000 h, Female = ~500 h; Hendry & Hodges, 2018). Similarly, a sample of Canadian recreational, yet competitive, male players participated in more than double the amount of play compared to National women players before the age of 16 yr (~1200 h; Hendry, Williams, Crocker, & Hodges, 2019). It is unclear why play volumes were relatively low in these elite female soccer players compared to males. It may be that opportunities to engage in play activities in childhood, at least among this current sample, were low (e.g., playground soccer). Some researchers have remarked that negative socio-cultural expectations exist (or have existed) for females engaging in soccer play outside of formalized practice (Williams, 2007).

The lack of between-group discriminability in soccer activities highlights a potential limitation of measuring only developmental activity quantity (*cf.*, Ericsson et al., 1993). Therefore, we also collected measures of challenge to assess how activity quality might have contributed to expertise development across all activities. In general, mean challenge ratings were relatively low, which is either indicative of sub-optimal coaching for the female players or perhaps indicative of the precocity of the players even in childhood, where playing soccer was deemed as relatively "easy". Incidentally, both National and Varsity players rated themselves as being within the top 10% of players within their respective teams throughout all stages of development (data not presented). Yet, accumulating more hours in moderate to high challenge soccer practice and play did successfully discriminate across the groups, with National players engaging in approximately 1000 h more "challenging" soccer activity than Varsity players during development. Given the lack of difference in total accumulated soccer activities and the small difference in accumulated soccer play hours, the between group differences in hours in moderate to high challenge activities suggests that activity quality may be key in discriminating across these groups of highly skilled female players based on childhood activities. This finding is consistent with our hypotheses based upon the challenge point framework (Guadagnoli & Lee, 2004).

Challenge ratings showed skill-group discriminability with respect to both activity type (e.g., play and practice) and age-period (e.g., childhood and adolescence). The fact that these challenge ratings

discriminated across groups of highly skilled athletes provides initial support for the validity of these methods. Across both skill groups, competition was rated as the most challenging activity and play the least, although competition did not significantly distinguish across groups ($p = .06$). In deliberate practice theory competition was viewed as "work", contributing little to expertise attainment. Quality competition in childhood (as operationalised through challenge) might yet show to be an important developmental activity for later success in sport.

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

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

In summary, we have presented data showing that world-class (National) and sub-elite (Varsity) female soccer players in Canada show developmental profiles which, similar to elite male players, highlight the importance of domain specificity, rather than sporting diversity, in developing soccer expertise. National team players participated in greater amounts (~500 more hours) and more challenging soccer play in childhood than less elite, Varsity players, although notably these overall amounts of play were low when compared with data reported for male players. Although they did not differ in total amounts of practice, they did differ in the hours spent in soccer practice deemed to be of moderate to high challenge. The differences across skill-groups with respect to challenge and hours in challenging activities paves the way for future research focusing on how best to measure and evaluate current domain specific activities using the challenge-point framework. Although the current data point towards player development profiles consistent with early specialization and somewhat, early (majority) engagement, the relatively low amounts of play versus structured practice from an early age and the increasing involvement in a variety of sports as the athletes developed, is not consistent with either pathway. There is therefore a need to validate and extend this research across different samples of adult female soccer athletes as well as current, female youth players. Prospective research with youth players at the elite levels should enable stronger conclusions about the pathways that are most conducive to success in soccer.

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