The nature of formative physical activities and sports in the development of senior volleyball players

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The nature of formative physical activities and sports in the development of senior volleyball players

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Abstract

This study characterized developmental sporting activities undertaken by volleyball players between ages of 6 to 12 years. Highly skilled (n=30) and less skilled (n=30) players participated in retrospective interviews to identify the nature of their formative enrichment experiences (formal adult-led and informal child-led activities) and types of sports practised (team or individual sports). All participants reported involvement in multiple formal sport activities and informal child-led activities, confirming that they did not specialize early in volleyball. Highly skilled male players reported being involved in more formal, adult-led activities, generally, and more formal team sports. In contrast, highly skilled and less skilled female players participated in equal amounts of formal adult-led and informal child-led activities. Results partially supported the value of an early diversified sport involvement to develop functional behavioural adaptability needed to specialise later in sports like volleyball. Findings highlighted the importance of considering the nature and types of early enriching play and practice activities to better understand possible complementary transfer of training effects during specialization. Data also emphasized relevance of considering sex differences in future analyses of player developmental pathways.

Key-words: practice, play, expertise, youth sports, talent development, sex differences

1. Introduction

Developmental activities and experiences of athletes are a key factor in acquiring expertise in sport, due to transfer effects and impact of early enrichment experiences on athlete development and later performance levels [1-4]. The question of which types, and amounts, of (specific and varied) sport experiences and physical activities can lead to long-term development and progress towards exceptional performance has been debated for some years [5, 6].

Some approaches to acquiring expert performance [7] have concluded that expertise is predicated on early investment in intense, highly structured, specific and effortful activities, which are not inherently enjoyable, defined as *deliberate practice*. A monotonic relationship has been proposed between a higher performance level, and a requisite amount of aggregated deliberate practice, deemed to take an average of 10,000 hours (over 10 years) to achieve. In order to acquire this proposed average level of deliberate practice in one domain, an early identification, selection and start was needed to maximise benefits of specialised practice [7]. As Ericsson et al. [7] noted, 'individuals who start early and practice at the higher levels will have a higher level of performance throughout development than those who practice equally hard but start later' (p. 392). These ideas gained prominence in the sport sciences in the late 1990s and early 2000s, driving an early specialisation approach to athlete development in talent pathways.

In recent years, clear evidence continues to emerge demonstrating that the developmental pathways of many elite performers may *not* require an average of 10,000 hours of deliberate, highly specialised practice and training [8-10]. Indeed, evidence from performance trajectories of many elite athletes indicates the value and benefit of diverse youth sport activities in both coach-led, structured and organised practice (in sport clubs, high-school sports or sport academies). Many studies have also signalled the

value of peer-led, unstructured and non-formally-organised activities, in both the athlete's primary sport as well as other sports [1, 11-13].

Accordingly, two contrasting developmental pathways to expert performance in sport have emerged in the literature: "early specialisation" and "early diversification" [5, 14, 15]. They differ in exclusivity of early, sport-specific practice (one sport or multiple sports), type of practice (structured/formal or unstructured/informal) and level of engagement (expressed as hours of practice) [5, 15]. Early specialisation (reflected in the framework of Deliberate Practice [7]) includes identification and selection of potential elite athletes at an early start age in a single sport, followed by early investment in focused intensive training, framed as deliberate practice. While this is currently a common pathway in sports where peak performance is achieved before adulthood/maturity (e.g. gymnastics, figure skating), some researchers have documented negative consequences associated with this approach to training, such as overuse injuries, decreased sport enjoyment, boredom, burnout and dropout [15-17]. In early diversification, on the other hand, children 'sample' a wide range of sporting activities (involving high levels of deliberate play and low levels of deliberate practice) primarily for enjoyment and, as a by-product, enrichment of functional athletic development, before specialising in a target sport. This approach is reflected in the Developmental Model of Sport Participation (DMSP) [18], indicated as an alternative to the early specialization pathway. It was argued that a more diversified sport engagement would avoid or reduce negative consequences associated with early specialization. An early diversified sport involvement was suggested because it may provide rich and varied experiences in a number of different physical, cognitive, affective and psychosocial dimensions. It is also suggested that diversification promotes several benefits that aid performance, and personal and social development [18-21].

Notwithstanding, the existing literature shows that each approach may be correlated with performance outcomes reported in some studies, but not in others [3].

There is a need for more research on these athlete developmental trajectories, partially due to the varied and ambiguous nature of the sporting activities that characterise these pathways, which impacts on direct empirical investigation [15]. Previous research has clarified that formal, adult-led activities provide positive formative experiences throughout the athlete's development [22-24]. Formal, adult-led activities include all kinds of formally-organized, adult-led training and competitive experiences, including instructed practices, designed to improve performance (specific structured practice, specific pedagogical games, formal competitions and tournaments) [1, 5]. On the other hand, informal, child-led activities include spontaneous games and play activities that are undertaken by children in their free time in environments like backyards, parks or streets with siblings and friends. These unstructured games and activities are typically characterized by their intrinsic values of enjoyment, play, and skill development [1, 5, 13, 25, 26]. Informal, child-led activities are widely recognized in the literature as important and complementary experiences in the course of personal and athletic development. Moreover, studies have shown evidence of benefits of informal child-led activities on the development of elite and highly skilled performers in many sports [12, 24, 26]. For example, in the study by Strafford and colleagues [12] experienced Parkour Traceurs were interviewed, discussing the importance of the powerful role of unstructured practice and exploratory activities in their learning and development. Many of them considered that the most enriching learning experiences and opportunities emerged during unstructured exploration and practice with peers, without a coach present to 'lead' the sessions, continually intervene with feedback and more. While there is a strong theoretical basis in motor learning theory for positive effects [14, 27], there

97 is a need for more data on specific benefits that may allow a better understanding of the
98 role of these activities on skill acquisition and athlete/talent development.
99 Past research has provided extensive information by recording participants'
100 reported involvement in formal organised sporting activities through retrospective
101 analysis (only structured, adult-led activities). But less information is available
102 concerning the variations in sports practised (sport-specific and non-sport specific play
103 and practice) [25]. Pedagogical approaches, like the Constraints-Led Approach (CLA) and
104 the Athletic Skills Model (ASM) [19, 27] are predicated on documented evidence from
105 actual practitioner interventions undertaken hourly, daily and weekly in sports
106 organisations. For example, the ASM documents outcomes of the relationship between
107 rich and varied sports experiences and skill acquisition in specialised sports training
108 programmes, capturing the effectiveness of experience in multiple sports and "donor
109 sports" and expertise acquired in a target sport. *Donor sports* include complementary
110 sport activities that enrich athletes by promoting transfer of varied and specific
111 movement skills and behaviours across a range of non-specific and specific practice
112 environments which support performance functionality at the specific moment of
113 specialisation [28, 29]. Abilities deemed critical to athlete development can be "*donated*"
114 by performance and experience in selected sports that share adjacent fields of an
115 affordance landscape including an extensive range of opportunities for action that can
116 support skills transfer from a donor sport to a target sport [19, 28]. An ecological dynamics
117 rationale explains that the enrichment process that learners undergo in a donor sport or
118 play activity (i.e. not necessarily formalised training in a sport), helps them to use
119 perception, action and cognition more effectively and efficiently in practice and
120 performance of their main sport. For example, it was proposed by Strafford et al. [28] how
121 participation in donor sports can enrich functional performance behaviours (e.g.,

cognition, perception and action) of learners. This theoretical rationale was supported by data of Oppici and colleagues [30]. They found that participation in futsal games led to three times the amount of recorded visual exploratory activity (scanning behaviours for information away from the ball) compared to football participation in the observations. These data were explained in the rationale of Travassos and colleagues [31] who discussed the potential skills transfer between futsal (acting as a donor sport) and Association Football (Soccer), exemplifying how general transfer could occur between these two sports.

Accordingly, informal child-led activities may also provide an important contribution to skill acquisition and expertise development [1, 13, 20, 21]. Although requiring more empirical evidence to complement the vast amount of practical information supporting the idea [15], these experiences may comprise a high degree of novelty and variability, exposing children to new physical, social and emotional situations, allowing them to explore their independence and enhance their organization and leadership skills [18, 20, 21]. Furthermore, flexibility in the structure and form of games may provide children with the freedom to drive their own learning, innovate games, adapt actions, and negotiate rules. Less structured play could engage children in developing characteristics of importance for behavioural development and performance in sport, such as innovation, resilience, self-regulation, creativity, adaptability, and flexibility [15, 21, 32, 33]. These features are considered the hallmark of adaptive skilled behaviour or dexterity [34, 35]. Despite the obvious functional relevance of informal, child-led activities in athletic development, more attention in the motor learning literature is needed to be given to their potential significance.

To summarise, early diversification of sport experiences and play/practice and performance environments (both formal and informal) might promote skills transfer by

147 exploiting affordance fields shared between sports and activities. More varied and
148 'donated' activities could develop functional behavioural adaptability needed to
149 enhance foundational athletic capabilities, prior to specialisation [36]. A careful, nuanced
150 and continuous transition between generality (non-target sports and activities) and
151 specificity (engaging with various forms of a target sport) of transfer is needed in talent
152 development [28, 36]. This approach seems to be particularly important in the early years of
153 athlete development (6-12 years) characterised as a sensitive period for effective motor
154 learning, in which children are able to learn very quickly and easily, with movements
155 effectively and rapidly modelled and skills acquired efficiently [19].

156 The present study extends our analysis of the development of volleyball players[1]
157 by re-analysing the data reported in our previous study and focusing on a specific period
158 of age (i.e. 6-12 years). Our intention was to scrutinize at what age players differ in their
159 perceptions of the number and type of activities they reported experiencing when aged
160 6, 7, 8, 9, 10, 11 and 12 years. By recording and comparing participant reports of annual
161 experiences of activities from 6-12 yrs of age, we sought to provide a more detailed
162 description of year-to-year variations in quantity and nature of sporting activities
163 experienced. These reported insights from participants could offer more concrete and
164 specific evidence about sport participation trajectories in such an important
165 developmental period for motor learning, skill acquisition and athlete development.
166 Therefore, the purpose of this study was to examine the developmental sporting
167 activities undertaken by highly skilled and less skilled volleyball players during the
168 development period of 6 to 12 years of age. Specifically, in this study we examined the
169 nature of the developmental sporting activities (i.e. formal adult-led and informal child-
170 led activities) and the types of sports practised (i.e. team or individual sports) during the
171 early years of development (6-12 years) of highly skilled and less skilled volleyball

players. The study also explored the potential sex differences in this characterization of sport participation in early years.

2. Materials and Methods

2.1. Participants

The athletes analysed in this study correspond to the sample of athletes being tracked by Coutinho and colleagues [1]. In that previous study we provided an initial global analysis of the sports participation histories of Portuguese volleyball players, taking into account three developmental stages: 6-12 years, 13-16 years, and 17-20 years. Our aim in the current study was to re-analyse the data reported in our previous study and undertake an in-depth analysis of the age period 6-12 years, scrutinizing what happened in the sport participation history of these volleyball players in each year of that developmental stage (i.e. when aged 6, 7, 8, 9, 10, 11 and 12 years). Accordingly, the original sample included highly skilled (HS; n=30) and less skilled (LS; n=30) volleyball players (15 males and 15 females in each group) (descriptive statistics for each of the four subsamples are presented in Table 1). Participants were selected using both purposive and convenience sampling criteria. Hence, they were chosen because they were considered information-rich in terms of having specialist knowledge and experiences concerning the research topic being investigated, as well as due to their capacity and willingness to participate in the study. Moreover, they were selected based on specific inclusion criteria, which are described in detail below. Generally, participants were selected based on two main criteria: being no younger than 23 years old (peak performance in volleyball is achieved in the mid to late twenties [37]), and having extensive experience of competitive participation (e.g., >7 yrs) in volleyball, but with no prior specification of the number of reported hours spent in sport participation.

Additional criteria to select HS participants included: playing in the Portuguese premier league [38], belonging to the Portuguese senior national team [39] and being ranked amongst the best volleyball players of the country by national team coaches [23]. The LS participants were selected based on the following criteria: playing in the Portuguese third league (the lowest competitive level, considered as recreational level volleyball) and had never been part of a senior or youth national team. Participants that do not meet all these criteria were not included in the sample. All procedures followed the guidelines stated in the Declaration of Helsinki and were approved by the ethics committee of the first author's institution. Participants were contacted personally and were provided with an overview of the study, with 100% participation agreement. Prior to the beginning of the study, all players were given information sheets that informed them about the purpose of the study and signed consent forms. Anonymity of the participants throughout the study was always assured.

* Please insert table 1 around here *

2.2. Data Collection

An adapted version of the retrospective interview procedure originally proposed by Côté, Ericsson and Law [40] was specifically designed to examine the sport participation histories of these volleyball players. The interview design sought to gain an in-depth understanding of participants' general patterns of activity involvement between 6 to 12 years of age. The concept "activities" included both sports (i.e. formal adult-led activities) and play (i.e. informal child-led activities), and includes: (i) the quantity (number of activities, both formal and informal); (ii) the nature (formal adult-led – FAL – and informal child-led – ICL); and (iii) the type of these activities (team and

individual sport). Team sports included activities practised by more than one person, involving cooperation between all members of the team/group and having shared competitive goals, or, in other words, team game sports – e.g., football, handball, basketball, volleyball, water polo. Volleyball (the main sports considered in this study) is included in this category and was not analysed separately. Individual sports included other activities rather than team game sports, in which they were practised by just one person, involving personal goals – example: gymnastic, track and field, tennis, swimming).

*** Please insert table 2 around here ***

Data were collected and presented in a series of tables and charts to provide an accessible and intuitive profile for both the primary researcher and the athlete. Interviews were conducted in a quiet area, familiar to participants and free from distractions, in a face-to-face format, and took approximately 2 hours to complete. All interviews were audio recorded and transcribed verbatim.

2.3. Data Analysis

Descriptive statistics were used to calculate frequencies, percentages, means and standard deviation values. The requirements of normality and homogeneity of variance were examined through the Kolmogorov-Smirnov test and Levene's test. Log transformations were conducted on some variables due to signs of non-normality (skewed data distribution). All variables examined from a developmental perspective used a 4 x 7 (groups x ages) analysis of variance with repeated measures (RM ANOVA). We considered four groups (highly skilled male, highly skilled female, less

skilled male and less skilled female) and seven different ages (6 years, 7 years, 8 years, 9 years, 10 years, 11 years and 12 years). Post hoc analyses were conducted using Bonferroni tests (Bonferroni adjusted alpha of $p = .001$) and effect sizes were determined using eta partial squared values (η^2_P). Greenhouse-Geisser adjustments were applied to mediate violations of the sphericity assumption for the RM variable. To assess the reliability of the information provided by participants in this study, follow-up interviews were conducted with 25% of the sample (15 players - three HS male, four HS female, four LS male, and four LS female) by the first author one month after the first period of data collection. Pearson product-moment correlations were calculated between the information collected at time one and time two. The reliability analysis was conducted separately for male and female participants. A total of twelve correlation coefficients were calculated as function of the nature (i.e., FAL and ICL) and type (i.e., general, team and individual) of sport activities from 6 to 12 years of age. The reliability assessment of male players showed high correlation coefficients for general (r = 0.968), team (r = 0.984) and individual (r = 0.7) FAL activities. Similarly, high correlation coefficient values were found in the analysis of general (r = 0.974), team (r = 0.978) and individual (r = 1) ICL activities practised by male players. Regarding female players, the reliability assessment revealed also high correlation coefficients for general (r = 0.992), team (r = 1) and individual (r = 0.978) FAL activities, as well as for general (r = 0.938), team (r = 0.905) and individual (r = 0.916) ICL sport activities. All the reliability coefficients aforementioned were statistically significant ($p < 0.000$).

3. Results

3.1. Number and type of FAL activities

Descriptive statistics for number and type of FAL activities experienced by HS and LS male and female players are presented in Table 3. A significant effect for age ($F_{(4,1)}$ = 8,849, p < 0,000, η^2_P = 0,240) and expertise level ($F_{(4,1)}$ = 0,736, p = 0,003, η^2_P = 0,274) on the male players' reported number of general FAL activities was found. Male players reported being involved in more general FAL activities at the ages of 10, 11 and 12 years (p = 0,003, p < 0,000, p < 0,000, respectively). The HS male players were involved in more FAL activities during this period compared to LS male players (p = 0,003). Regarding the number of team FAL activities experienced, a significant effect for age ($F_{(3,1)}$ = 7,128, p < 0,000, η^2_P = 0,333) and expertise level ($F_{(3,1)}$ = 4,124, p = 0,05, η^2_P = 0,128) was found. Male players reported being involved in more team FAL activities at the ages of 10, 11 and 12 years (p < 0,000, p < 0,000, p < 0,000, respectively). The HS male players were involved in more team FAL activities during this period, compared to LS male players (p = 0,05). There were no significant main effects for age and expertise level on players' reported number of individual FAL activities experienced.

Concerning the number of general FAL activities reported by female players, a significant effect for age ($F_{(3,1)}$ = 6,788, p = 0,015, η^2_P = 0,123) was found. Female players reported being involved in more general FAL activities at the ages of 10, 11 and 12 years (p = 0,002, p = 0,003, p = 0,002, respectively). Regarding the number of team FAL activities undertaken, a significant effect for age ($F_{(3,1)}$ = 8,453, p < 0,000, η^2_P = 0,232) was observed. Female players were involved in more team FAL activities at the ages of 10, 11 and 12 years (p = 0,025, p = 0,001, p = 0,001, respectively). Reports of the number of individual FAL activities undertaken revealed a significant effect for age ($F_{(3,1)}$ = 2,947, p = 0,05, η^2_P = 0,095). Female players were involved in more individual FAL activities at the ages of 9 and 10 years (p = 0,005, p < 0,000, respectively).

296

297 * Please insert table 3 around here *

298

299 ***3.2. Number and type of ICL activities***

300 Descriptive statistics for number and type of ICL activities experienced by HS and LS
301 male and female players are presented in Table 3. A significant effect for age ($F_{(2,1)}$ =
302 8,131, p = 0,001, η^2_P = 0,225) on male players' reported number of general ICL
303 activities was found. Male players reported being involved in more general ICL
304 activities at the ages of 10, 11 and 12 years (p = 0,002, p = 0,001, p = 0,001,
305 respectively). Regarding the number of team ICL activities undertaken by male players,
306 a significant effect for age ($F_{(2,1)}$ = 7,916, p = 0,001, η^2_P = 0,220) was found. Male
307 players were involved in more team ICL activities at the ages of 10, 11 and 12 years (p
308 = 0,005, p = 0,003, p = 0,003, respectively). There were no significant main effects for
309 age and expertise level on male players' reported number of individual ICL activities.

310 Concerning the number of general ICL activities experienced by female players,
311 a significant effect for age ($F_{(2,1)}$ = 4,289, p = 0,020, η^2_P = 0,133) was found. Female
312 players reported being involved in more general ICL activities at the ages of 9, 10, and
313 11 years (p = 0,014, p = 0,006, p = 0,018, respectively). Regarding the number of team
314 ICL activities experienced, a significant effect for age ($F_{(2,1)}$ = 4,041, p = 0,019, η^2_P =
315 0,126) was found. Female players were involved in more team ICL activities at the ages
316 of 9, 10, 11 and 12 years (p = 0,032, p = 0,018, p = 0,028, p = 0,017, respectively).
317 There were no significant main effects for age and expertise level on the number of
318 reported individual ICL activities.

319

320 **4. Discussion**

This study compared the developmental sporting activities undertaken by HS and LS volleyball players, at each year, between the ages of 6 to 12 years, specifically considering the nature of these formative experiences and types of sports experienced. We also explored potential sex differences in this characterization of early sport participation. Globally, results indicated that both HS and LS participants were involved in multiple FAL activities and ICL activities, demonstrating that they did not specialize early in volleyball. Conceptually, reported experiences of both groups corresponded to the "early diversification" pathway reflected in the DMSP [18], characterized by sampling different sports during the early years of athletic development and involvement in both FAL and ICL play and practice activities [18, 41]. This pathway has been associated with several benefits, including a well-documented reduced health-related risk (later emergence of overuse injuries) [17, 42, 43] and hypothesized positive effects on prolonged engagement, enjoyment, reduced burnout, healthy psychological and social development [15, 18, 41, 44]. These ideas are clearly aligned with theoretical proposals that talent development in young sport participants is predicated on two phases: one of early enrichment of athletic capacities before the secondary specialization period of dedicated practice in a target sport [19, 45].

Specifically considering participation in FAL activities, HS male participants were involved in more activities compared to their LS counterparts. These findings are consistent with the theoretical tenets of the DMSP [18] and numerous retrospective studies on team sports that empirically evidenced that elite players engage extensively in various sports, before specializing in the main sport [1, 25, 46-48]. The findings also support the theoretical proposal of Côté and colleagues [16, 18] suggesting that early diversification does not hinder elite sport participation in sports where peak performance is reached after maturation, as observed in the majority of team sports. These findings also

highlighted sex specificities and differences, with participation in FAL activities being a differentiating factor only between male players. This could indicate a greater involvement, commitment to the sport and consistency in coach-led practice throughout time by male players (in particular HS male players), which consequently could be reflected in their performance enhancement. Also, social influences, with female players having fewer opportunities for practising sports, could be reflected here. Regarding the type of sports practised, although some caution is needed in interpreting these results (particularly effect size values), the HS male participants indicated a greater involvement in team sports compared to individual sports. Accordingly, it is possible that team sports could have acted here as complementary *donor sports* to provide varied and specific experiences across a range of non-specific and specific practice environments which support performance functionality at the moment of specialization [12, 19, 28, 29]. Team sports share adjacent areas or fields of an *affordance landscape* [49] that include an extensive range of opportunities for action which can transfer functional performance behaviours. Here, transfer of learning could have emerged in differing ways shaped by use of more general movement behaviours, perceptual and contextual similarities, and opportunities for expression of cognitive functions (i.e. problem-solving and decision making under pressure) and physical conditioning capacities. For example, participating in other team sports may have helped players in enriching and refining motor coordination (players developed patterns of coordination that best suit different contextual demands), a better spatial orientation (players developed the skill of maintaining orientation across a wide variety of circumstances - distances, number of players, type of the game, etc.), an enhanced capacity for decision making (players have to decide differently based on time and space restrictions, characteristics of the sport - invasion / non-invasion - number of players involved, etc), enriched athleticism and

physical conditioning skills, and rigorous attitude to improvement in training culture (players know how to train, seeking to continually improve, understand how to respect rules, and how to collaborate and accomplish goals within a team sport environment). This finding is aligned with the ecological dynamics theoretical framework emphasizing that talent development and learning in sport implies a nuanced transition between generality and specificity of practice and transfer [36, 45, 50, 51]. According to some theoretical explanations, varied experiences might favour exploratory and adaptive behaviours, inviting participants to satisfy different interacting constraints, educating their attention and intentions to specify what needs to be achieved in a performance context [36]. These experiences may have provided HS male players with a rich landscape of affordances that helped them to develop functional behavioural variability, potentiating perceptual-motor exploration, considered a hallmark of skilled behavior (termed 'dexterity' by Bernstein [34]; see also Chow and colleagues [14]). Nonetheless, there are still some questions regarding the role of *donor sports* that remain unanswered and should be explored in future studies. According to the original concept of *donor sports*, the beneficial effects of other sport experiences is moderated by the relatedness between other sports and a target sport. However, several studies have also demonstrated the importance of other "unrelated" sports for later performance development (captured at the multisports phase in the ASM continuum). Also, the possibilities of skill transfer have been examined between coach-led practice (i.e. formal, coach-led sports), and there is a need for more research on the transfer between child-led play (i.e. informal, child-led activities) and a target sport. While an ecological dynamic framework, in line with concepts from the ASM/donor sports, has the potential to advance our understanding on skill acquisition and talent development in sport, further empirical research is needed to clarify these issues.

Considering involvement in FAL activities by female participants, HS and LS participants reported participating in essentially the same number of these activities (both general, team and individual activities), with an increased participation between 10 and 12 years of age. This type of diversified sport involvement could have *donated* important capacities or skill components that facilitated their holistic development, helped them to exploit functional patterns of coordination, as well as enhanced cognition, perception and action, relevant requisites for supporting subsequent performance in volleyball [19, 36]. Moreover, more than recording the number of sports experienced, it is important to contemplate the microstructure of daily practice experiences (especially their nature and quality). This approach will help investigators to understand whether practice tasks are functionally relevant and contain informational constraints that promote exploration, discovery and adaptation in learners. This finding also highlighted the importance of considering sex differences in analyses of participants' developmental pathways. Female athletes are clearly underrepresented across all topics of talent development research and results are extrapolated to females without due consideration of the impact of that transfer [52]. Therefore, failing to account for the experiences of females in talent development research can result in excluding and ineffective talent development systems and sub-optimal experiences for female athletes [52-54].

Regarding participation in ICL activities, both groups (HS male, LS male, HS female and LS female participants) were involved in several ICL activities (both general, team and individual activities), with greater intensity between 10 and 12 years of age. Although the involvement in ICL activities did not differentiate between groups, the findings are consistent with empirical evidences of some previous studies on team sports demonstrating that players were involved in ICL activities [1, 12, 25]. According to

theoretical explanations, involvement in this type of activity allows children to experience sports in various contexts with freedom to invent, adapt, create, and negotiate activities and rules to suit to their own wishes and needs [18, 21]. Their high degree of novelty and variability expose children to new physical, technical, tactical and cognitive situations, allowing them to develop important characteristics of expertise in sport, such as innovation, creativity, adaptability, and flexibility [20, 21, 32]. Notwithstanding, although ICL activities and play was positively correlated with later performance in some studies [1, 12, 33] , the experience in these activities was not correlated or was negatively correlated with later performance in other studies [22]. Our study demonstrated that both HS and LS players (male and female) were involved in considerable quantities of ICL activities between 6-12 years of age, but the quantity of these experiences was not statistically correlated with their later performance. Considering the majority of studies on this topic have tended to only examine *the quantity* of these experiences, it is important for further studies to consider *the quality* of informal child-led experiences in order to better understand the role of this type of activities on enriching athlete and talent development.

Despite the important findings of this study, there are some limitations that should be addressed. Although used widely in the literature, reliable and valid, retrospective methodologies and data mining techniques only reflect interpretation of records and participants' reports/perceptions of their previous sport experiences, which need to be triangulated with other objective data regarding developmental patterns [55]. Further studies are needed to consider the potential of multi-year prospective and multi-cohort designs to specifically examine the athletes' developmental sport experiences to better understand the contributions of diversified sport activities to developing expertise in sport. A detailed examination of the microstructure of practice and play could

provide relevant insights into how the specificity/generality of information could lead to specificity/generality of skill transfer. Thus, contemporary research methods in sport science and pedagogical science may need further evidence of participant perception of the type of practice activities, as well as quantity of relevant units in their practice histories, such as hours or number of activities undertaken. The selected methods, therefore, need to go beyond mere data mining since researchers need to ensure that they are not disrupting, nor distorting the perceptions of the lived experiences of participants (whether coaches or athletes). Here, exploring the use of qualitative research methods (such as in-depth interviews, engaging with focus groups, participant observation, action research, ethnographic studies) may provide a more consistent and deeper way to enrich understanding of the role of practice and play activities in determining expertise achievement. These investigations are likely to help researchers better understand how training transfer facilitates athlete development.

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643 *Table 1 - Descriptive statistics (mean and standard deviation) for age, sport starting age, volleyball*
644 *starting age and age of volleyball specialization of Highly Skilled and Less Skilled players (male and*
645 *female)*

	HS Male	LS Male	HS Female	LS Female
Age	27,1 ± 3,1	26,3 ± 2,9	27,4 ± 3,5	26,7 ± 2,6
Sport Starting Age	6,6 ± 2,7	7,1 ± 2,6	8,1 ± 2,9	7,8 ± 3,1
Volleyball Starting Age	10,1 ± 3,7	10,6 ± 3,7	11,7 ± 2,5	10,9 ± 2,2
Age of Volleyball Specialization	10,1 ± 2,1	11,1 ± 3,3	13,9 ± 2,1	12,3 ± 1,7

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Table 2 - Description of the nature and type of activities

Formal adult-led activities	Informal child-led activities
- Activities in general (general activities) - Team sports - Individual sports	- Activities in general (general activities) - Team activities - Individual activities

Table 3 – Descriptive statistics (mean and standard deviation) for number of formal adult-led and informal child-led activities experienced by Highly Skilled and Less Skilled players (male and female)

	Formal Adult-led Activities				Informal Child-led Activities			
	General				General			
Ages	**HS Male**	**LS Male**	**HS Female**	**LS Female**	**HS Male**	**LS Male**	**HS Female**	**LS Female**
6 years	1,07 ± 0,59	0,50 ± 0,51	0,73 ± 1,03	0,73 ± 0,79	0,87 ± 1,12	0,73 ± 1,10	1,07 ± 1,03	1,33 ± 1,23
7 years	1,07 ± 0,45	0,80 ± 0,67	0,93 ± 0,96	1,00 ± 1,41	1,07 ± 1,22	0,93 ± 1,10	1,33 ± 1,17	1,33 ± 1,23
8 years	1,20 ± 0,67	0,73 ± 0,59	1,07 ± 1,10	1,07 ± 1,38	1,33 ± 1,39	0,93 ± 1,10	1,73 ± 1,03	1,67 ± 1,54
9 years	1,40 ± 1,05	0,80 ± 0,67	0,93 ± 0,96	1,60 ± 1,35	1,53 ± 1,40	1,00 ± 1,30	1,73 ± 1,16*	1,80 ± 1,69*
10 years	1,73 ± 1,10*	0,87 ± 0,64*	1,00 ± 0,92*	2,27 ± 1,87*	1,73 ± 1,53*	1,07 ± 1,43*	1,93 ± 1,10*	2,00 ± 1,85*
11 years	1,80 ± 1,14*	1,07 ± 0,59*	1,07 ± 0,79*	1,93 ± 1,48*	1,93 ± 1,62*	1,27 ± 1,66*	1,80 ± 1,14*	2,07 ± 1,79*
12 years	2,13 ± 0,99*	1,40 ± 0,73*	1,07 ± 0,88*	1,67 ± 1,44*	1,93 ± 1,58*	1,40 ± 1,76*	1,53 ± 1,24	1,93 ± 1,66
	Team				Team			
	HS Male	**LS Male**	**HS Female**	**LS Female**	**HS Male**	**LS Male**	**HS Female**	**LS Female**
6 years	0,53 ± 0,51	0,27 ± 0,45	0,20 ± 0,56	0, 33 ± 0,61	0,67 ± 0,81	0,33 ± 0,61	0,27 ± 0,45	0,47 ± 0,83
7 years	0,67 ± 0,48	0,53 ± 0,64	0,27 ± 0,59	0,40 ± 0,63	0,80 ± 0,86	0,40 ± 0,63	0,27 ± 0,45	0,47 ± 0,83
8 years	0,87 ± 0,51	0,53 ± 0,51	0,27 ± 0,59	0,27 ± 0,59	1,00 ± 1,06	0,40 ± 0,63	0,40 ± 0,50	0,67 ± 0,90
9 years	0,93 ± 0,88	0,60 ± 0,50	0,33 ± 0,61	0,53 ± 0,74	1,07 ± 1,03	0,47 ± 0,74	0,47 ± 0,64*	0,80 ± 1,01*
10 years	1,20 ± 0,77*	0,80 ± 0,56*	0,40 ± 0,63*	0,93 ± 0,96*	1,20 ± 1,01*	0,53 ± 0,91*	0,60 ± 0,63*	0,80 ± 1,01*
11 years	1,27 ± 0,70*	1,00 ± 0,53*	0,53 ± 0,64*	1,13 ± 0,83*	1,33 ± 1,17*	0,73 ± 1,16*	0,60 ± 0,63*	0,87 ± 0,99*
12 years	1,67 ± 0,97*	1,27 ± 0,59*	0,80 ± 0,67*	1,07 ± 0,70*	1,33 ± 1,17*	0,93 ± 1,33*	0,53 ± 0,64*	0,87 ± 0,83*
	Individual				Individual			
	HS Male	**LS Male**	**HS Female**	**LS Female**	**HS Male**	**LS Male**	**HS Female**	**LS Female**
6 years	0,53 ± 0,64	0,20 ± 0,41	0,33 ± 0,48	0,60 ± 0,98	0,20 ± 0,41	0,40 ± 0,63	0,80 ± 0,77	0,87 ± 0,74
7 years	0,40 ± 0,73	0,27 ± 0,59	0,53 ± 0,51	0,60 ± 0,91	0,27 ± 0,59	0,53 ± 0,64	1,07 ± 0,88	0,87 ± 0,74
8 years	0,33 ± 0,61	0,20 ± 0,41	0,67 ± 0,72	0,80 ± 0,86	0,33 ± 0,61	0,53 ± 0,64	1,33 ± 0,81	1,00 ± 0,92
9 years	0,53 ± 0,64	0,20 ± 0,41	0,53 ± 0,74*	1,07 ± 0,79*	0,47 ± 0,64	0,53 ± 0,64	1,27 ± 0,88	1,00 ± 0,92
10 years	0,53 ± 0,83	0,13 ± 0,35	0,53 ± 0,64*	1,20 ± 0,94*	0,53 ± 0,74	0,53 ± 0,64	1,33 ± 0,81	1,20 ± 1,08
11 years	0,53 ± 0,91	0,13 ± 0,35	0,53 ± 0,64	0,73 ± 0,88	0,53 ± 0,64	0,60 ± 0,73	1,20 ± 0,86	1,20 ± 0,96
12 years	0,47 ± 0,64	0,20 ± 0,41	0,27 ± 0,45	0,60 ± 0,82	0,53 ± 0,64	0,53 ± 0,74	1,07 ± 0,88	1,07 ± 1,10