

# EXPERTISE DEVELOPMENT IN VOLLEYBALL: THE ROLE OF EARLY SPORT ACTIVITIES AND PLAYERS' AGE AND HEIGHT

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## Abstract:

The purpose of this study was to analyse the developmental pathway of skilled and less skilled volleyball players by focusing on the quantity and type of sporting activities, as well as their age and height in comparison to peers in those experiences. Retrospective interviews were conducted to provide a longitudinal and detailed account of sport involvement of 30 skilled and 30 less skilled volleyball players (15 male and 15 female players per group) throughout different developmental stages (stage 1: 8-12 years; stage 2: 13-16 years; stage 3: 17-20 years). Results indicated that the developmental pathway of these volleyball players (i.e. skilled and less skilled) was characterized by an early diversified sport involvement with a greater participation in sport activities during stages 1 and 2. However, skilled players specialized later in volleyball (between age 14 and 15) and performed more hours of volleyball at stage 3 (from 17 years of age onwards). Also, skilled players (male and female) were younger in both the diversified sport activities and volleyball at the later stages of development (i.e. stages 2 and 3), and skilled female players were taller than peers in those activities in the early stages of development (i.e. stages 1 and 2). The present findings suggest early diversification as a feasible pathway to reach expertise in volleyball and highlight the importance of practicing with older peers once specialization in the main sport has occurred. The findings highlight the need for coaches and sport programs to consider different stimuli existing within the training environment (i.e. characteristics of athletes, such as age and height) that influence the quality of practice and contribute to players' expertise development.

**Key words:** talent development, sport experience, practice, age, height

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## Introduction

The unique nature of sport results in a need to understand the processes by which athletes develop their expertise. The examination of expert athletes' lifelong developmental pathways sheds light on the particular factors that influence the achievement of high levels of performance in adulthood. A central topic in this research field has been the examination of the benefits and costs associated with various types of practice performed during different stages of athletic development (Baker, Cobley, & Fraser-Thomas, 2009; Baker, Côte, & Deakin, 2006; Barreiros, Côte, & Fonseca, 2013; Berry, Abernethy, & Côte, 2008; Leite, Baker, & Sampaio, 2009; Leite, Santos, Sampaio, & Gomez, 2013; Lloyd, et al., 2014a). Early specialization and early diversification have been considered as two possible approaches that lead to expertise in sport (Baker, 2003; Baker, et al., 2009; Côte, Baker, & Abernethy, 2007; Côte, Murphy-Mills, & Abernethy, 2012; Davids & Baker, 2007; Leite, et al., 2013).

Early specialization means an early start age in doing one specific sport and an early investment in deliberate practice (i.e. highly structured and intensive activities, with the explicit goal of improving performance) (Baker, 2003; Baker, et al., 2009; Côte, et al., 2007, 2012; Ericsson, Krampe, & Tesch-Romér, 1993). Although a positive and monotonic relationship between the amount of deliberate practice and achieved level of performance has been suggested in the literature (Baker, Côte, & Abernethy, 2003b; Baker, Côte, & Deakin, 2005; Berry, et al., 2008; Coutinho, Mesquita, Fonseca, & De Martin-Silva, 2014; Ford, Ward, Hodges, & Williams, 2009; Ward, Hodges, Starkes, & Williams, 2007), a focus on specialized training during the early stages of development has been associated with several negative consequences, such as injuries, decreased enjoyment, burnout, and dropout (Baker, 2003; Baker, et al., 2009; Fraser-Thomas & Côte, 2009; Fraser-Thomas, Côte, & Deakin, 2008a, 2008b; Law, Côte, & Ericsson, 2007; Lloyd, et al.,

2014b). Furthermore, recent studies carried out in team sports have shown that players have achieved expert performance after accumulating 4,000 to 6,000 hours of sport-specific practice (Baker, et al., 2005, 2006; Berry, et al., 2008; Soberlack & Côté, 2003), which is far less than the 10,000 hours suggested in the literature as a benchmark for attaining expertise (Ericsson, 2013; Ericsson, et al., 1993).

On the other hand, early diversification is based on the notion that children “sample” a wide range of sport activities during childhood and experience high levels of deliberate play (i.e. unstructured early developmental activities, which that are intrinsically motivating, provide immediate gratification and are specifically designed to maximize enjoyment) (Côté, Baker, & Abernethy, 2003; Côté, et al., 2007; Côté, Erickson, & Abernethy, 2013; Côté, Lidor, & Hackfort, 2009; Côté, et al., 2012). Participating in a variety of sport activities allows children to experience a number of different physical, cognitive, affective, and psychosocial environments, which may enhance their intrinsic motivation that stems from fun, enjoyment, and competence children experience in sport (Côté, et al., 2007, 2013; Côté & Fraser-Thomas, 2008; Côté, Horton, MacDonald, & Wilkes, 2009; Côté, Lidor, et al., 2009). Furthermore, early diversification is associated with sport participation that usually continues into late adulthood, having therefore a protective effect against negative consequences such as injuries, burnout and dropout (Baker, 2003; Baker, et al., 2009; Fraser-Thomas & Côté, 2009; Fraser-Thomas, et al., 2008a, 2008b).

The developmental trajectories of expert and non-expert athletes have been retrospectively investigated through questionnaires (e.g. Allen, Vandenberg, & Hopkins, 2014; Gulbin, Oldenzel, Weissensteiner, & Gagné, 2010; Leite, et al., 2009) and structured interviews (e.g. Hayman, Polman, Taylor, Hemmings, & Borkoles, 2011; Johnson, Tenenbaum, Edmonds, & Castillo, 2008) in order to provide a detailed account of the quantity (i.e. number of hours, number of sports) and type (i.e. structured and non-structured activities, specific and non-specific sport activities, deliberate practice, deliberate play) of practice performed by those athletes (Baker, et al., 2005; Ford, et al., 2009; Haugaasen, Toering, & Jordet, 2014; Hayman, Borkoles, Taylor, Hemmings, & Polman, 2014; Helsen, Starkes, & Hodges, 1998; Leite, et al., 2013). Overall, studies have suggested that the achievement of elite performance through early specialization and deliberate practice has been more common in sports where the peak of performance is reached before adulthood, such as gymnastics or figure skating (Deakin & Cobley, 2003; Law, et al., 2007). On the contrary, elite performance through early diversification and deliberate play has been frequently observed in sports where the peak of

performance is achieved during adulthood, such as triathlon, rowing, tennis and a large number of team sports like basketball, volleyball, ice-hockey or football (Baker, Côté, & Abernethy, 2003a; Baker, et al., 2003b; Berry, et al., 2008; Coutinho, et al., 2014; Leite & Sampaio, 2012; Leite, et al., 2013). Furthermore, studies have also indicated that the achievement of expertise is usually associated with a greater quantity of practice performed by expert players when compared to their non-expert counterparts (Baker, et al., 2005; Coutinho, et al., 2014).

Despite the importance of such studies in characterizing athletes’ developmental pathways, to date little attention has been given to the influence of other relevant factors on the course of an athlete’s development. A more multidisciplinary and integrative focus has been proposed by several researchers (Davids & Baker, 2007; Phillips, Davids, Renshaw, & Portus, 2010) who have considered the role of other interacting components that shape the development of expert performance in sport, such as environmental circumstances or the athlete’s anthropometric characteristics (Balish & Côté, 2013; Côté, MacDonald, Baker, & Abernethy, 2006; Ericsson, et al., 1993; MacDonald, Cheung, Côté, & Abernethy, 2009; MacDonald, King, Côté, & Abernethy, 2009). In terms of environmental circumstances, researchers have highlighted the role of playing partners in developing skills during the early exposure to sport activities (Balish & Côté, 2013; Côté, et al., 2006; MacDonald, Cheung, et al., 2009). Although there has been little research done on this topic, the existing information indicates that professional athletes have played with (or against) older peers at a young age and those experiences were important contributors to their expertise achievement (Côté, et al., 2006; MacDonald, Cheung, et al., 2009). In the same vein, Balish and Côté (2013) studied one athletically successful Canadian community and suggested that the opportunity to participate in older and more competitive teams was a key factor in developing expertise of talented athletes. As regards athletes’ anthropometric characteristics, research has shown that height is a core factor in achieving a high level of performance in volleyball (Gualdi-Russo & Zaccagni, 2001; Lidor & Ziv, 2010; Malousaris, et al., 2008; Martín-Matillas, et al., 2014; Zaccagni, Onisto, & Gualdi-Russo, 2009). However, little is known about the characterization of the athletes’ height throughout their development (which may include the participation in both the diversified sport activities and the main sport) and its influence on expertise development and achievement. Considering the specific demands of volleyball, playing this sport with either shorter or taller peers throughout one’s developmental stages may lead to different sport experiences and ultimately could affect expertise development.

To date, only few studies have examined the effect of gender in the development of team sport athletes (Coutinho, et al., 2014; Leite & Sampaio, 2012) and highlighted several differences in the pathways of male and female players. Overall, research has shown that female players are often involved in a reduced number of early sporting activities and competitions, which indicate that they have fewer opportunities to practice and compete on a regular basis throughout their developmental stages (Coutinho, et al., 2014; Leite & Sampaio, 2012). Furthermore, Coutinho and colleagues (2014) analysed the developmental pathway of skilled and less skilled volleyball players (male and female) and found that the early involvement in individual sports by skilled female players was an important factor in their route to expertise. Indeed, the achievement of expertise in such different contexts (i.e. men's and women's sport) is dependent on several factors (e.g. training constraints and conditions, opportunities, financial support), which could lead to different developmental pathways. This evidence highlights the need to take gender differences and expertise level into consideration in the study of expert performance in sport so as to provide adjustable long-term athlete developmental programs.

Therefore, the purpose of this study was twofold. First, we retrospectively analysed the sport participation trajectory of skilled (male and female) and less skilled (male and female) volleyball players throughout three stages of their development (stage 1: 8-12 years, stage 2: 13-16 years, and stage 3: 17-20 years). Second, we examined players' age and height in comparison to peers in different contexts of sport activities (i.e. diversified sports activities, DSA, and volleyball) throughout their development.

## Methods

### Participants

Participants were 60 volleyball players divided into four groups: 15 skilled male, 15 skilled female, 15 less skilled male, and 15 less skilled female players. Skilled players (male and female) were selected based on the following criteria: (1) having no less than 23 years of age; (2) having a minimum of 10 years of volleyball experience (when these players were interviewed, they had an average of 20 years of experience); (3) playing in the Portuguese first league (in Portugal, male and female adult players compete in a semi-professional national competitive system composed of the first, second and third leagues, in which the first league is the most competitive and the third league is the least competitive); (4) competing nationally and internationally; (5) being a member of the senior national team (in the moment of data collection); and (6) being amongst the best volleyball players as deter-

mined by a panel of eight coaches (they had more than 15 years of experience and were experienced coaches of the first league and/or senior national teams; their decision was based on deep knowledge of the players, as well as of their performance indicators). Less skilled players (male and female) were selected taking into account the following criteria: (1) having no less than 23 years of age; (2) having a minimum of 10 years of volleyball experience; (3) playing in the Portuguese third league (i.e. a lower competitive level); (4) compete only nationally; and (5) not ever being a member of the senior national team. Prior to the study, all players were informed about the purpose of the study and they signed consent forms. All procedures followed the guidelines stated in the Declaration of Helsinki and the affiliated university granted ethical approval for the research project.

### Procedure

All players participated in a semi-structured interview intended to outline the sport experiences of volleyball players. The interview was a Portuguese adapted version of the Côté, Ericsson, and Law's (2005) retrospective interview procedure evaluated by a panel of four experts. It was designed to assess quantitative data of players' general pattern of sport involvement and players' characteristics throughout their sport experiences. The procedure included primarily closed-ended questions and was focused on four main areas: demographic information, general sport involvement, volleyball-specific involvement, and player's age and height in comparison to peers throughout their sport participation. The specific variables collected in each section are indicated in Table 1.

In order to examine these variables from a developmental perspective, the data collected were arranged to cover events in athletes' development from 8 to 20 years of age. The *Developmental Model of Sport Participation* (Côté, 1999; Côté, et al., 2003, 2007) was used as a theoretical framework to define the developmental stages considered in this study. Acknowledged as one of the most prominent conceptualizations of athlete development (Bruner, Erickson, McFadden, & Côté, 2009; Bruner, Erickson, Wilson, & Côté, 2010; Côté & Vierimaa, 2014), this model considers early specialization (i.e. involvement solely in one sport since an early age) and early diversification (i.e. involvement in several sports in the early years of development and then specialization in one sport) as two possible pathways to expert performance in sport. Specifically considering the early diversification pathway, athletes may develop through three different stages, namely the *sampling years* (age 6-12 years; involvement in a wide range of sport activities and deliberate play), the *specializing years* (age 13-16 years; engagement in fewer sport activities

and a balanced amount of deliberate practice and play), and the *investment years* (age 16+ years; commitment to only one sporting activity with a large amount of deliberate practice). While taking into account these age marks, we also considered the Portuguese Volleyball Federation's competitive system so as to contextualize and validate the ages at each stage considered in this study. Therefore, three different developmental stages were defined: stage 1 (8-12 years), stage 2 (13-16 years), and stage 3 (17-20 years).

Data were collected in a series of tables and charts designed to assemble the information in an easily understood and intuitive profile for both the primary researcher and the athletes (Côté, et al., 2005). This interview was conducted as a one-on-one format in a quiet location that was free from distractions, and it took approximately 90 minutes per interview to complete. All data were audio recorded.

### Reliability of retrospective information

The usefulness of our proposed methodology is critically dependent on the validity and reliability of the reported information (Côté, et al., 2005). While providing information for more recent events is relatively reliable, the information regarding activities undertaken much earlier in the players' development may not provide similarly accurate recall (Côté, et al., 2005). Research on memory has provided some evidence regarding substantial forgetting and bias in the long-term memory of activities

and experiences (Bahrack, Hall, & Berger, 1996; Côté, et al., 2005). Therefore, there is a need to consider strategies to assess the reliability of the information elicited in retrospective interviews. Côté and colleagues (2005) proposed the test-retest approach as an avenue to assess the reliability of the information elicited in retrospective interviews (Barreiros, et al., 2013; Hayman, Polman, & Taylor, 2012; MacDonald, Horton, et al., 2009). To assess the reliability of the information provided by players in this study, follow-up interviews were conducted a month later with 25% of the sample (15 players – three skilled males, four skilled females, four less skilled males, and four less skilled females), which is above the minimum recommended reference value. Pearson product-moment correlations were calculated from the information collected at the two points, showing high consistency (with correlations ranging from .802 to .995).

### Statistical analysis

All the variables examined from a developmental perspective used a 4 x 3 (group x stage) repeated measures analysis of variance (RM ANOVA) across stages (stage 1: 8-12 years, stage 2: 13-16 years, and stage 3: 17-20 years). Specifically, the RM ANOVA was used to examine the number and hours of DSA practiced, as well as the number of hours of volleyball practice throughout the players' development. Additionally, a one-way ANOVA was used to compare groups (i.e. skilled males, skilled females, less skilled males, and less skilled females) for each

Table 1. Characterization of the variables analysed in each section of the interview

Demographic information
<ul style="list-style-type: none"> <li>• Gender</li> <li>• Birthdate</li> <li>• Birthplace</li> <li>• Level of competition (i.e. first, second or third league)</li> </ul>
General sport involvement
<ul style="list-style-type: none"> <li>• Age of the first sport participation</li> <li>• Number of DSA (formal practice done in a club or school for at least one year – volleyball included)</li> <li>• Number of hours of practice of DSA practised per year</li> </ul>
Volleyball specific involvement
<ul style="list-style-type: none"> <li>• Age of the first participation in volleyball</li> <li>• Age of specialization in volleyball (when players started to practice only volleyball)</li> <li>• Number of volleyball practice hours per year</li> </ul>
Player's age and height in comparison to peers
<ul style="list-style-type: none"> <li>• Player's age in comparison to peers or teammates in DSA and volleyball (players were asked whether they were younger, older, or had the same age in relation to peers for each age and for each sport activity they participated in)</li> <li>• Player's height in comparison to peers or teammates in DSA and volleyball (for each age, players were asked if they were shorter, taller, or had the same height in relation to peers for each age and for each sport activity in which they participated in)</li> </ul>

Note: These variables were collected for each age and sport activity. We calculated frequency of the answers (i.e. the number of times the players were younger, of the same age, older, shorter, of the same height, taller) for each age and then for each stage (i.e. frequency of answers between 8 and 12 years, between 13 and 16 years, and between 17 and 20 years).

variable. Specifically, a one-way ANOVA was used to examine the age of the first participation in DSA and volleyball, the age of specialization in volleyball, as well as the number and hours of DSA and the number of hours of volleyball practice in each stage. Likewise, a one-way ANOVA was used to examine players' age and height in relation to peers/teammates throughout their involvement in DSA and volleyball at each stage. *Post-hoc* analyses were conducted using Bonferroni tests. Eta-squared values ( $\eta^2$ ) were calculated to determine effect sizes and interpreted by the following criteria: statistically significant but weak ( $\eta^2 \leq .04$ ), moderate ( $.04 \leq \eta^2 \leq .36$ ), and strong ( $\eta^2 > .36$ ) (Tabachnick & Fidell, 2007). The analyses were carried out in SPSS, version 22.0, and the statistical significance was set at  $p \leq .05$ .

## Results

### Early sport activities

**The age of first sport participation and specialization in volleyball.** Descriptive statistics for age of the first sport participation and volleyball, as well as age of specialization in volleyball (when players started to practice only volleyball) are presented in Table 2. While no significant differences were found between groups for the age of the first sport participation or first participation in volleyball, significant differences were found for the age of specialization in volleyball ( $F_{(3,59)}=6.494$ ,  $p=.001$ ,  $\eta^2=.258$ ). Skilled male and female players started their specialization later in life than less skilled male players ( $p=.001$  and  $p=.011$ , respectively).

**Involvement in DSA and hours of volleyball practice.** Descriptive statistics for the number

and hours of DSA are presented in Tables 3 and 4. While there was no difference between groups in the number of DSA, the significant differences by stage were found for this variable ( $F_{(2,112)}=22.938$ ,  $p<.001$ ,  $\eta^2=.291$ ). Players were involved in more DSA during stage 1 ( $M=3.0$  sports/year,  $SD=.2$ ) and stage 2 ( $M=2.3$  sports/year,  $SD=.2$ ) than at stage 3 ( $M=1.6$  sports/year,  $SD=.1$ ). Concerning the number of hours of DSA, the significant differences between groups were found in the hours of DSA practiced per year ( $F_{(3,59)}=21.684$ ,  $p<.001$ ,  $\eta^2=.537$ ), as well as in the overall accumulated number of hours of DSA ( $F_{(3,59)}=4.815$ ,  $p=.005$ ,  $\eta^2=.205$ ). Skilled male and female players were involved in more practice hours during stage 3 than less skilled male ( $p<.000$  and  $p=.001$ , respectively) and less skilled female ( $p<.000$  and  $p=.001$ , respectively) players. Moreover, skilled male and skilled female players accumulated more hours of DSA across all the stages than less skilled male players ( $p=.001$  and  $p=.030$ , respectively).

**Volleyball.** Descriptive statistics for the number of practice hours of volleyball are presented in Tables 3 and 4. The significant differences by stage were found ( $F_{(2,112)}=159.880$ ,  $p<.001$ ,  $\eta^2=.741$ ), with players being involved in more practice hours of volleyball at stage 2 ( $M=1130.0$  hours/year,  $SD=483.0$ ) and stage 3 ( $M=1710.0$  hours/year,  $SD=889.4$ ) than at stage 1 ( $M=406.0$  hours/year,  $SD=333.0$ ). Moreover, the significant differences between groups were found for the hours of volleyball practiced per year ( $F_{(3,59)}=20.185$ ,  $p<.001$ ,  $\eta^2=.520$ ) and for the overall accumulated number of practice hours of volleyball (from 8 to 20 years) ( $F_{(3,59)}=6.783$ ,  $p=.001$ ,  $\eta^2=.267$ ). The skilled male and female players were involved in more practice hours

Table 2. Mean (M) and standard deviation (SD) for age of the first sport participation, as well as the first participation and specialization in volleyball

	Skilled male		Skilled female		Less skilled male		Less skilled female	
	M	SD	M	SD	M	SD	M	SD
First sport participation	6.6	2.8	8.1	3.0	7.1	2.6	7.9	3.1
First participation in volleyball	10.1	3.7	11.7	2.5	10.1	3.7	11.0	2.2
Age of specialization in volleyball	15.0	2.1	14.0	2.1	12.2	1.7	13.0	2.7

All the statistical differences are described in the section Results.

Table 3. Mean (M) and standard deviation (SD) for the number and hours of DSA (Diversified Sport Activities), as well as hours of volleyball examined from a developmental perspective

	8-12 years		13-16 years		17-20 years		Total (8-20 years)	
	M	SD	M	SD	M	SD	M	SD
No. of DSA	3.0	1.8	2.3	1.4	1.6	0.9	6.8	3.1
Hours of DSA	1079.0	1113.0	1419.0	602.0	1750.0	897.1	4247.0	1975.1
Hours of volleyball	406.0	333.0	1130.0	483.0	1710.0	889.4	3245.0	1262.2

All the statistical differences are described in the section Results.

Table 4. Mean (M) and standard deviation (SD) for the number and hours of DSA (Diversified Sport Activities), as well as hours of volleyball according to expertise level and gender

		No. of DSA		Hours of DSA		Hours of volleyball	
		M	SD	M	SD	M	SD
Skilled males	8-12 years	3.7	2.1	1060.0	615.0	347.2	285.4
	13-16 years	3.1	1.1	1501.0	564.1	1093.0	530.9
	17-20 years	1.9	1.0	2671.0	1051.0	2589.0	1088.0
	Total	2.9	0.3	5231.2	1478.0	4029.0	1610.2
Skilled females	8-12 years	2.6	1.6	1197.3	1887.0	324.1	342.9
	13-16 years	1.9	1.2	1721.0	751.4	1357.0	635.0
	17-20 years	1.7	0.9	2060.0	565.1	2041.0	555.1
	Total	2.1	0.3	4978.0	2715.0	3721.4	1151.2
Less skilled males	8-12 years	2.5	1.1	798.4	386.2	399.0	366.2
	13-16 years	2.2	1.4	1155.3	285.0	947.0	286.1
	17-20 years	1.3	0.7	1142.0	158.0	1137.0	159.1
	Total	2.0	0.3	3096.0	457.0	2483.0	706.4
Less skilled females	8-12 years	3.1	2.1	1258.4	999.4	553.3	315.0
	13-16 years	1.8	1.6	1298.0	606.0	1122.0	350.0
	17-20 years	1.4	0.8	1127.2	347.4	1073.0	291.0
	Total	2.1	0.3	3683.2	1819.3	2748.0	713.0

All the statistical differences are described in the section Results.

of volleyball during stage 3 than the less skilled male ( $p<.000$  and  $p=.001$ , respectively) and less skilled female ( $p<.000$  and  $p=.001$ , respectively) players. Additionally, the skilled male and female players accumulated more practice hours of volleyball across all the stages than the less skilled male players ( $p=.002$  and  $p=.017$ , respectively).

### Players' age and height in comparison to peers

**Involvement in DSA.** Descriptive statistics for players' age and height in comparison to peers throughout DSA are presented in Table 5. As regards players' age, the significant differences were found between groups in stage 2 ( $F_{(3,59)}=5.833$ ,  $p=.002$ ,  $\eta^2=.238$ ) and stage 3 ( $F_{(3,59)}=12.500$ ,  $p<.001$ ,  $\eta^2=.401$ ). The skilled male players were younger than the less skilled male players during stage 2 ( $p=.010$ ) and stage 3 ( $p=.001$ ), and the skilled female players were younger than the less skilled female players during stage 3 ( $p<.001$ ). Concern-

ing players' height, the significant differences were found between groups in stage 1 ( $F_{(3,59)}=3.774$ ,  $p=.015$ ,  $\eta^2=.168$ ) and stage 2 ( $F_{(3,59)}=5.833$ ,  $p=.002$ ,  $\eta^2=.203$ ). The skilled female players were taller than the less skilled female players during stage 1 ( $p=.032$ ) and stage 2 ( $p=.041$ ).

**Volleyball.** Descriptive statistics for players' age and height in comparison to peers throughout their volleyball involvement are presented in Table 5. Concerning players' age, the significant differences were found between groups in stage 3 ( $F_{(3,59)}=14.864$ ,  $p<.001$ ,  $\eta^2=.443$ ). The skilled male players were younger than the less skilled male players during stage 3 ( $p=.004$ ), and the skilled female players were younger than the less skilled female players during stage 3 ( $p<.001$ ). Concerning players' height, the significant differences were found between groups in stage 2 ( $F_{(3,59)}=3.654$ ,  $p=.018$ ,  $\eta^2=.164$ ). The skilled female players were taller than the less skilled female players during stage 2 ( $p=.015$ ).

Table 5. Mean (M) and standard deviation (SD) for players' age and height in comparison to peers throughout participation in DSA (Diversified Sport Activities) and volleyball

		Age*												Height**											
		DSA						Volleyball						DSA						Volleyball					
		Younger		Same age		Older		Younger		Same age		Older		Shorter		Same height		Taller		Shorter		Same height		Taller	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Skilled males	8-12	1.2	1.1	2.7	1.2	0.1	0.3	1.1	1.8	2.1	1.8	0.0	0.0	1.0	1.5	1.4	1.7	1.3	1.7	2.1	2.6	0.4	0.9	0.7	1.4
	13-16	1.1	0.8	2.5	1.4	0.1	0.3	1.7	2.4	3.2	2.1	0.1	0.5	0.8	1.2	0.8	1.2	1.9	2.0	2.1	2.8	1.0	1.6	1.8	2.1
	17-20	2.0	1.0	1.3	0.9	0.3	0.6	5.1	2.6	2.1	1.5	0.6	1.2	1.0	1.4	0.8	1.1	1.7	2.1	3.1	4.3	2.2	3.5	2.5	2.5
	Total	4.3	1.7	6.5	2.2	0.5	0.8	7.9	5.4	7.5	4.0	0.7	1.4	2.8	3.7	3.0	3.2	5.0	4.9	7.4	9.2	3.6	5.3	5.0	5.1
Skilled females	8-12	0.9	0.9	1.8	1.6	0.1	0.3	0.4	0.6	1.1	1.5	0.0	0.0	0.5	0.8	0.7	1.2	1.7	1.4	0.4	1.3	0.1	0.5	0.9	1.3
	13-16	1.1	0.5	1.9	1.2	0.1	0.3	0.0	0.0	3.1	2.4	0.1	0.5	0.3	0.7	1.2	1.1	1.5	0.8	0.7	1.8	1.9	1.7	2.9	2.6
	17-20	1.8	0.9	0.9	0.9	0.1	0.2	5.7	3.0	1.7	1.8	0.1	0.5	0.4	0.7	1.3	1.0	0.9	1.1	1.3	2.3	3.8	3.7	2.8	3.7
	Total	3.9	1.6	4.6	2.8	0.2	0.6	8.4	4.7	5.9	4.0	0.3	1.0	1.3	1.9	3.1	2.4	4.1	1.8	2.4	4.7	5.8	5.0	6.7	5.6
Less skilled males	8-12	0.4	0.8	2.3	0.9	0.0	0.0	0.1	0.3	2.3	2.1	0.0	0.0	0.7	1.0	1.3	1.2	0.5	0.9	0.5	1.2	0.7	1.2	1.1	2.0
	13-16	0.3	0.5	2.1	1.5	0.1	0.5	0.2	0.6	3.5	0.8	0.0	0.0	0.3	0.5	1.2	1.3	1.1	1.2	0.9	1.5	1.7	1.6	1.1	1.6
	17-20	0.9	0.4	1.3	0.9	0.0	0.0	2.3	1.0	2.0	1.4	0.0	0.0	0.3	0.5	0.8	0.9	0.5	0.8	1.2	1.8	2.1	2.1	0.9	1.6
	Total	1.5	1.1	5.7	2.5	0.1	0.5	2.5	1.5	7.7	2.5	0.0	0.0	1.3	1.6	33.3	2.5	2.1	2.6	2.6	3.8	4.5	3.9	3.2	4.5
Less skilled females	8-12	0.9	0.8	1.9	1.3	0.5	1.6	0.3	0.9	1.9	1.2	0.2	0.8	1.1	1.2	1.8	1.8	0.4	0.7	0.7	1.6	1.5	1.5	0.4	1.1
	13-16	0.5	0.8	1.6	1.2	0.1	0.5	0.1	0.4	3.3	1.4	0.1	0.5	0.6	0.6	1.3	1.7	0.3	0.5	1.0	1.5	2.5	1.9	0.7	1.2
	17-20	0.6	0.6	1.1	0.9	0.2	0.6	1.2	1.7	2.6	2.1	0.5	1.2	0.7	0.6	0.6	0.5	0.1	0.4	2.0	2.4	2.0	1.9	0.5	1.3
	Total	2.1	1.4	4.5	2.7	0.8	1.8	2.2	3.1	7.8	3.7	0.8	1.8	2.3	2.9	3.7	3.4	0.8	1.1	3.7	4.7	6.0	4.0	1.5	2.4

All the statistical differences are described in the section Results. \* The number of times players were younger, of the same age or older when compared to their peers/teammates (throughout the stages). \*\* The number of times players were shorter, of the same height, or taller when compared to their peers/teammates (throughout the stages).

## Discussion and conclusions

The purpose of this study was to characterize the developmental pathway of volleyball players by considering their early developmental sport activities (quantity and type of practice) and their age and height when compared to their peers, while also considering a simultaneous analysis of expertise level and gender. In terms of developmental sport experiences, the volleyball players analysed in this study had an early diversified sport participation and a late specialization in the main sport, which is in line with studies carried out in team sports (Baker, et al., 2003a, 2003b; Barreiros, et al., 2013; Berry, et al., 2008; Coutinho, et al., 2014; Leite, et al., 2009; Leite & Sampaio, 2012; Leite, et al., 2013). These findings indicate that early diversification does not hinder the achievement of elite levels in sports in which peak performance is reached after maturation (such as volleyball) (Balyi & Hamilton, 2004). The age of peak performance in these sports usually occurs after the athlete has fully matured, which allows the athlete to sample a variety of sports before specializing in the main sport (around age 13) and investing in sport-specific training (around age 16) (Côté, et al., 2007; Côté, Lidor, et al., 2009; Côté, et al., 2012). Such experiences may lead to positive outcomes for long-term athletic development, such as

high levels of intrinsic motivation and a prolonged commitment to practice (Côté, Horton, et al., 2009; Côté, Lidor, et al., 2009; Fraser-Thomas & Côté, 2009; Fraser-Thomas, et al., 2008a, 2008b; Lloyd, et al., 2014a). In contrast, the earlier specialization (around age 12) of the less skilled male players in our study may have restricted the participation in other sport activities and, consequently, limited the development of important skills for attaining expertise in the main sport. Accordingly, a key advantage of early diversification relies on the development of important motor, physical, cognitive, and social skills (Côté, Horton, et al., 2009; Côté, Lidor, et al., 2009; Fraser-Thomas & Côté, 2009; Fraser-Thomas, et al., 2008a, 2008b; Lloyd, et al., 2014a) that may be further transferred to the sport in which the athlete later specialises (Abernethy, Baker, & Côté, 2005; Broadbent, Causer, Williams, & Ford, 2014; Collins, Collins, MacNamara, & Jones, 2014). However, little is yet known about the possible transfer of learning across different sport activities experienced at the early stages of development and of its contribution to sport expertise.

Although previous research has highlighted the benefits of playing and practicing with older peers (Abernethy, 2008; Balish & Côté, 2013; Côté et al., 2006; MacDonald, Cheung, et al., 2009; MacDon-

ald, King, et al., 2009), these experiences may not have the same relevance at different stages of an athlete's career. Our findings suggest that skilled players took advantage of practicing with older peers during stages 2 (13-16 years) and 3 (17-20 years), i.e. when they specialized and invested in the main sport (volleyball). At these particular stages of athletic development, older peers may have played an important role by providing a more demanding and challenging training environment, which may have boosted the quality of practice and contributed to players' expertise development. Therefore, the players' age seems to be an important factor that could determine their response to training stimuli (Abade, et al., 2014). Furthermore, the superior height of skilled female players at the early stages of development (i.e. stages 1 and 2) could have been an advantage in overcoming technical and tactical issues with skills that are usually not fully developed at the early stages of development (where the main focus is to provide a diversified and enjoyable practice environment before specializing in the main sport). Accordingly, Lidor and Ziv (2010) reviewed physical characteristics of adolescent volleyball players and indicated that the taller the female player, the better was her volleyball skill proficiency and game performance. The lack of a rationale for such information limits the possibility to discuss the influence of player's height on expertise achievement, but encourages further research to explore these issues.

Several practical implications can be drawn from the present study. Firstly, early specialization may not be a necessary requirement for expertise achievement in volleyball, which should lead sport practitioners to consider early diversification as an alternative pathway for attaining a high level of performance in this sport. Secondly, the opportunity to train and compete with older peers during specialization should be a worthy variable to consider in talent identification processes and tasks design in volleyball since it can influence quality of practice and contribute to players' expertise development. Thirdly, coaches should consider the player's height as an advantageous factor for volleyball skill proficiency and game performance during the early stages of development, while also adopting a cautious approach when attempting to predict the success of players based on their physical characteristics. Finally, coaches and sport systems should consider the relevance of these issues when designing long-term volleyball players developmental programs.

Despite the important findings of this study, there are some limitations that should be addressed. The Portuguese volleyball is not among the world top-level class, which should motivate other researchers to examine the developmental pathways of high-level volleyball players. Furthermore, the retrospective interviews have been considered an incomplete tool to collect accurate data in this research field (Côté, et al., 2005); however this methodology reflects the players' perception of their previous sport experiences failing to provide objective data regarding their developmental patterns (Sosniak, 2006). Future studies should consider the potential of prospective longitudinal designs to specifically examine the players' developmental sport experiences, as well as their contextual characteristics (e.g. players and teammates' age and height) so as to better understand the contributors to developing and attaining expertise in volleyball. Here, the detailed examination of the microstructure of practice could provide important insight into what really differentiates learning activities performed at different stages of development by skilled and less skilled players. Furthermore, qualitative methodologies should also be considered in further studies as a valuable procedure for in-depth analysis and interpretation of the processes of athlete and talent development.

In conclusion, the present findings indicate that early diversification may be a feasible pathway to reach expertise in volleyball. However, there are other important contributors to the achievement of expert performance in this sport, namely the number of hours of specific practice and practice with older peers once the specialization in the main sport has started. Moreover, the differences between the developmental pathways of male and female players (e.g. the advantage of being taller for skilled female players during the early stages of development) highlight the need to consider gender as a worthy variable to explore in further studies so as to get a better understanding of the processes underpinning talent development. These findings highlight the need for coaches and sport programs to consider different stimuli of training environment (i.e. characteristics of athletes, such as age and height) since they can influence quality of practice and contribute to players' expertise development. This study provides important insight into the development of volleyball players thereby affording important evidence for designing adjustable long-term athlete developmental programs.

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