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Research article

Paths to expertise in Portuguese national team athletes

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Abstract
The purpose of this study was to identify the quantity and type of sporting activities undertaken by expert team sport athletes in the earlier stages of the long-term athlete development. Experts in roller-hockey (n = 19), volleyball (n = 14), soccer (n = 42) and basketball (n = 37) provided detailed information about the sporting activities they undertook throughout their careers. Results showed considerable variation between and within sports; however, generally, athletes began participating in sports between 6 and 10 years of age. The pattern of participation in specific and non-specific (team, individual and combat) sports for each stage of involvement demonstrated an increase in the number of activities participated in until early adolescence. Our results suggest that involvement in multiple sports during early stages of development is an alternative to early specialization and add further evidence of the complexity of skill acquisition in sport.

Key words: performance, specialization, skill acquisition.

Introduction

The historical debate on the influences of genes and environment on human behavior has been characterized by extreme positions leading to reductionist and polemic conclusions. Recently, Davids and Baker (2007) concluded there is little support for either biologically or environmentally deterministic perspectives on elite athletic performance. Despite advances concerning the defining characteristics and components of expert sports performers, the development of expertise and the identification of talent in sports remains an important issue of debate (e.g., Ericsson, 2007; Klissouras et al., 2007).

Case history evidence from elite sports players (e.g., Côté et al., 2003) suggest that, at some point, effective skill development eventually becomes linked with, or even dependent on, a planned and deliberate skill development program. Indeed, recent research examining the long-term development of talent (Abbott and Collins 2004; Balyi, 2002; Bailey and Morley, 2006) suggests that planned skilled development programs are important from as early as 6 or 7 years if children are to gain the early motor, cognitive and emotional skills crucial for a lifetime association with physical activity. Studies of expertise development have provided several models to explain progression from novice to expert (e.g., Abbott and Collins 2004; Côté et al., 2003). For instance, Côté et al. (2003) suggested key periods in the development of sporting expertise where the influence of participation in a wide range of activities, and not just the sport of prime interest, is important. Recent investigations by this research group revealed that athletes pass through three stages of sport participation (i.e., sampling, specializing, and investment years) prior to the attainment of expert level performance. During these stages there is a shift from activities that are play-like in nature to more structured and effortful training activities. In addition, the number of sport-specific training hours dramatically increases from initial involvement in the sampling years to committed involvement in the investment years (Baker et al., 2003).

Researchers examining the early stages of development in elite athletes (e.g., Carlson, 1988; Côté, 1999; Hill, 1993) have reported that early specialization during childhood does not seem to be essential for exceptional sport performance as an adult. In a recent study of expert decision-makers in basketball, netball, and field hockey, Baker et al. (2003) proposed that participation in other relevant activities (e.g., other sports where dynamic decision-making is necessary) during early phases of development improved the physical and cognitive skills necessary to their main sport. They also suggested that experts characteristically receive exposure to a wide range of sports in their developing years and that these additional sport experiences reduce the amount of sport-specific training needed to become an expert. In their study, the number of hours of practice needed to become an expert was inversely related to the breadth of the initial sporting experience. In other words, the greater the number of activities the athletes experienced and practiced in their developing years, the less deliberate, domain-specific practice was necessary to acquire expertise within their sport of specialization. This result leads to the proposition that additional sports experiences during the developing/sampling years contribute to subsequent attainment of domain-specific expertise.

Currently, there is some research to support the possibility of transfer of perceptual learning for simple, artificially-generated patterns (e.g. Allen and Brooks, 1991; Goldstone, 1998), forms of cognitive knowledge across the same domain (e.g. Gott et al., 1992), and from perceptual-motor simulations to more natural situations (e.g. Lee et al., 2001). However, in the motor domain, historical notions of specificity have dominated (Barnett et al., 1973) and reviews of the literature usually conclude that transfer between motor tasks, where it exists, is small unless the two tasks are so similar as to be practically identical (Schmidt and Young, 1987).

More recently, Abernethy et al. (2005) examined whether the facilitation of expertise associated with other

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sport experience might arise from positive transfer of pattern recall skills from one sport to another. Expert netball, basketball and field hockey players and experienced non-experts (the same athletes examined in the study by Baker et al., 2003) performed a recall task for patterns of play derived from each of these sports. Experts from sports different to those shown in the presented pattern consistently outperformed non-experts in their recall of defensive player positions, suggesting some selective transfer of pattern recall skills was possible. Thus, a more comprehensive understanding of the practice base essential for expert performance, especially team sports, requires consideration of not only the sport-specific practice activities undertaken but also the type and extent of experience accumulated in other sports.

One approach which appears to offer some insight into the development of expert attributes and a more comprehensive understanding of the expertise development in team sports involves using retrospective accounts to trace the detailed life histories of selected experts. While there are still relatively few studies of the developmental histories of sports experts, there appear to be a number of key contextual factors that strongly influence the development of expert performance. Unsurprisingly, critical elements appear to be both the quantity and type of practice undertaken by an individual (e.g. Ericsson et al., 1993; Helsen et al., 1998; Hodges and Starkes, 1996). This approach to the study of expertise focuses upon examining the developmental pathways to expert performance, seeking commonalities between experts in the type of practice and contextual environments they experienced. The purpose of the current study was to identify the quantity and type of sporting activities undertaken by expert athletes in team sports in the early stages of athlete development and the communalities in the backgrounds of the experts from four different team sports (roller-hockey, volleyball, soccer and basketball) that may have contributed to their unique expertise.

Methods

Participants

One hundred and twelve expert male athletes served as participants, including 19 roller-hockey athletes, 14 volleyball athletes, 42 soccer athletes and 37 basketball athletes, all chosen from the Portuguese national men's teams. At the time of data collection, each of the teams was highly ranked internationally. The men's roller-hockey and soccer teams participated in the last World championships (in 2007 and 2006 respectively), while the men's volleyball and basketball teams participated in the European championships (in 2005 and 2007 respectively). Each athlete was recognized by their respective national team coaches as being amongst the best athletes in their particular sports. All coaches from each respective national team agreed unanimously on the athletes' selection for the present study.

Procedures

The sample provided important comparative data concerning their developmental stages as suggested by training methodology specialists (Bompa, 1994) and reinforced by the *Long-Term Athlete Development* proposal for Late Specialization Sports (Stafford, 2005), specifically from INitiation (6 to 10 years of age), ORientation (11 to 14 years), SPecialization (15 to 18 years) and High-level Performance (19 years and beyond).

The procedure included a questionnaire designed to collect information on the acquisition of high-level performance in sport. This procedure elicits verifiable information on the development of athletes' quantity and quality of practice in their main sport, as well as other sports they participated in during their career. The collected information was then examined to identify aspects of the athletes' recall that met criteria of validity and reliability. A general limitation of studies examining retrospective information is ensuring the validity and reliability of the information collected. When athletes are required to answer questions based on recall of past episodic and habitual experiences, these individuals should be more accurate and reliable than when they are forced to reconstruct answers to general questions (see Ericsson & Simon, 1993, for the theoretical rationale). Therefore, we choose to question the athletes about general issues related to their experiences across their sports career, reducing the effect of current beliefs or opinions about their development (Côté et al., 2005). Prior to the athlete data collection, the questionnaire was validated by sports training experts in several steps. First, a preliminary version of the questionnaire was designed based on available research. This version was then reviewed by five specialists in training theory and methodology to verify the importance, clarity and understanding of questions identified in Step 1. After the evaluation by the training specialists, some of the initial questions were excluded and only those questions that had the agreement of at least four of the five specialists were retained. Finally, the questionnaire was administered to the athletes.

Questionnaire completion was conducted in a quiet group environment, lasting between 30 minutes and 1 hour. Due to the level of the teams, time for data collection was minimal and, as a result, participants completed the questionnaire in a group setting. However, each athlete completed their questionnaire independently (i.e., there was no group discussion), after receiving group instructions from the lead researcher. The purpose of the questionnaire was to develop a detailed longitudinal account of each athlete's involvement in specific and non-specific sport activities. The initial part of the questionnaire was devoted to the establishment of a comprehensive set of variables related to long-term athlete development, specifically the *Sports starting age* and the *Main sport starting age*. The specific instructional set used to elicit information during this phase of data collection was:

> *I would like you to focus on the activities that you were involved in during your career, from your earliest sport involvement until nowadays. I would like to know when you started practicing sports and when you started practicing your main sport [roller-hockey, volleyball, soccer or basketball] in particular.*

The second part of the questionnaire assessed the amount and type of activities that the athlete participated in throughout their development. At the same time, ath-

letes were asked about the amount of time they spent per week in those activities across the four different stages: initiation, orientation, specialization and high-level performance. Lastly, in each of those developmental stages athletes were questioned about their participation in official competitions. Therefore, this section of the questionnaire was composed by 16 items, 4 for each developmental stage. The following instructional set was used to elicit this information:

Looking back over your sporting career please tell me of any type of activity that you were engaged in on a regular basis. What sport activities, if any, were you participating in before becoming seriously involved in your main sport? Please list all of these activities and for each of the four different developmental stages listed in the chart: initiation, orientation, specialization and high-level performance, and provide the number and type of sporting activities and minutes per week you were involved. Finally, specify the sports where you participated in games/competitions.

Athletes reported the duration of participation using the following ordinal scale 0, 1 to 60 minutes, 61-120 minutes, 121-180 minutes, 181 to 240 minutes, 241 to 300 minutes, or greater than 300 minutes. An ordinal scale was chosen due to concerns about the limits of athletes' recall of this type of information. For instance, we assumed athletes would be able to adequately recall whether then trained for between 1 and 2 hours (i.e., 61 to 120 minutes) but may not be able to precisely recall the specific number of minutes.

Statistical analysis

To test for statistical differences among the four groups' long-term developmental variables, non parametric Mann-Whitney U tests were performed. Alpha was set at .05. Bonferroni adjustments were applied to correct for multiple tests. To validate the athletes' self-reported practice minutes per week, the intraclass correlation analysis was calculated between the number of practice minutes per week estimated by the athlete and the comparable estimate provided by their parents. All data were analyzed with the statistical package SPSS for Windows, release 16.0 (SPSS Inc., Chicago, IL).

Reliability of retrospective information

As the questionnaire task relied extensively on the retrospective recall of the athletes involved, and because of the complexity and depth of information the athletes were required to recall, measures were taken to cross-validate the data provided by the athletes. Previous research has relied largely upon the use of one-week training diaries to validate retrospective information provided by athletes (Helsen et al., 1998; Hodges and Starkes, 1996). This information, as seen in Côté et al. (2005), while providing valid information for more recent events, may not provide an accurate recall of activities undertaken much earlier in the athlete's development. Reliability of the number and type of early activities and the average minutes of practice/week provided by the expert athletes was done by temporal stability of the measures, thus, 10% of the sample was asked to refill the questionnaire one month after the first data collection. To examine the correspondence between the numbers of activities reported by the athletes at both time points the percent agreement (Bahrick et al., 1996) was computed. There was a complete agreement (100%) between the information given by the athletes in both moments. To establish validity, a sample of the athletes' parents (n = 7), specifically the parent deemed by each athlete as most knowledgeable about their sports career, was asked to confirm the number and type of early activities and minutes of practice provided by the expert athletes (Baker et al., 2003). There was also complete agreement (100%) between the total number of activities reported by the athletes and the total reported by their parents. The correlation coefficient for the number of practice minutes per week estimated by the athlete and the comparable estimate provided by their parent was $r = 0.61$ ($p < 0.05$). Collectively, these results indicate the data are reasonably valid and reliable.

Results

Long-term developmental variables

The long-term developmental variables are presented in Table 1. Results showed that the majority of athletes in all groups began participating in sports between 6 and 10 years of age; however, results also demonstrated that a significant minority started practicing after 10 years of age (28.6% of volleyball players, 7.1% of soccer players, and 31.2% of basketball players). Furthermore, 14.2% of volleyball players and 5.2% of basketball players did not begin regular participation in sport until after 15 years of age. The roller-hockey athletes are the exception to this later starting age with 100% of players beginning involvement in sports between the ages of 6 and 10 years. Results revealed significant differences in the *Sport starting age* between roller-hockey and basketball ($z = -2.779$; $p = 0.001$) and between soccer and basketball ($z = -3.011$; $p = 0.001$).

Table 1. Descriptive and inferential statistics for long-term development variables.

	Age (yrs)	Roller-hockey	Volleyball	Soccer	Basketball
Sport starting age	6-10	100	71.4	92.9	68.8
	11-14	-	14.3	7.1	26.0
	15-18	-	7.1	-	5.2
	≥19	-	7.1	-	-
Main sport starting age	6-10	100	28.6	90.5	41.6
	11-14	-	35.7	9.5	48.1
	15-18	-	28.6	-	10.4
	≥19	-	7.1	-	-

* Significant differences were at $p < 0.001$, with a) Roller-hockey vs. Volleyball, b) Roller-hockey vs. Soccer, c) Roller hockey vs. Basketball, d) Volleyball vs. Soccer, e) Volleyball vs. Basketball, f) Soccer vs Basketball.

Table 2. Descriptive and inferential statistics for developmental stages variables.

Developmental stages	Roller-hockey				Volleyball				Soccer				Basketball			
	IN	OR	SP	HP	IN	OR	SP	HP	IN	OR	SP	HP	IN	OR	SP	HP
Number of sports practiced																
0	-	-	-	-	28.6	14.3	7.1	-	9.5	-	-	-	18.2	3.9	-	-
1	52.6	63.2	78.9	94.7	42.9	50.0	92.9	100	54.7	90.5	97.6	100	31.2	71.4	98.7	100
2	21.1	21.1	10.5	5.3	7.1	21.4	-	-	33.3	9.5	2.4	-	28.6	23.4	1.3	
3	21.1	10.5	5.3	-	14.3	14.3	-	-	2.4	-	-	-	16.9	1.3	-	-
≥4	5.3	5.3	5.3	-	7.1	-	-	-	-	-	-	-	5.2	-	-	-
Type of sports practiced																
None	-	-	-	-	28.6	14.3	7.1	-	9.5	-	-	-	18.2	3.9	-	-
Main team sport	52.6	63.2	78.9	94.7	21.4	50.0	92.9	100	54.7	88.1	97.6	100	13.0	66.2	98.7	100
Other team sports (TS)	-	-	-	-	28.6	21.4	-	-	-	-	-	-	14.3	5.2	-	-
Individual sports (Individual)	-	-	-	-	-	-	-	-	-	-	-	-	9.1	1.3	-	-
Combinations of several sports	47.4	36.9	21.0	5.3	21.3	14.3	-	-	35.7	14.4	2.4	-	45.5	23.4	1.3	-
Average minutes per week																
None	-	-	-	-	28.6	14.3	7.1	-	9.5	-	-	-	18.2	3.9	-	-
60 minutes	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-	-	-
60-120 minutes	-	-	-	-	7.1	-	-	-	2.4	2.4	-	-	2.6	-	1.3	-
120-180 minutes	-	-	-	-	-	-	-	-	11.9	-	-	-	10.4	1.3	-	-
180-240 minutes	26.3	-	-	-	42.9	28.6	7.1	-	9.5	7.1	4.8	2.4	18.2	3.9	-	-
240-300 minutes	26.3	31.6	10.5	-	14.3	35.7	28.6	-	26.2	16.7	-	-	11.7	16.9	2.6	-
300 minutes	47.4	68.4	89.5	100	7.1	21.4	57.1	100	40.5	73.8	95.2	97.6	37.7	74.0	96.1	100
Participation in competition																
None	-	-	-	-	28.6	14.3	7.1	-	9.5	-	-	-	18.2	3.9	-	-
Yes	100	100	100	100	64.3	85.7	92.9	100	90.5	97.6	100	100	62.3	96.1	98.7	100
No	-	-	-	-	7.1	-	-	-	-	2.4	-	-	19.5	-	1.3	-

All statistical significant differences are described in the results section.

The results of the *Main sport starting age* confirmed this exception for the roller-hockey group; all of the players began practicing roller-hockey between 6 and 10 years of age. Similarly, most soccer athletes also started between 6 and 10 years with only 10% starting their main sport after 10 years of age. Volleyball and basketball athletes were more variable in the age at which they began their main sport. Statistical analyses revealed significant differences in *Main sport starting age* between roller-hockey and volleyball ($z = -4.270$; $p = 0.000$), roller-hockey and basketball ($z = -4.416$; $p = 0.000$), volleyball and soccer ($z = -4.796$; $p = 0.000$) and between soccer and basketball ($z = -5.163$; $p = 0.000$), but not between volleyball and basketball.

Developmental stages

Table 2 describes the number and type of sporting activities (main and additional) expert athletes participated in prior to attaining the high-level performance stage. Based on previous work (Almond, 1986), sporting activities were categorized into four mutually exclusive categories: main sport, team sports, individual sports and combat sports. The number of additional sporting activities athletes' participated in decreased as athletes progressed to specialization in the main sport. Between 6 and 10 years of age, athletes participated in several sports, sometimes in each of the 4 different sport categories. This increase usually continued until late adolescence. Following this, involvement in other sports gradually declined in number and type until specialization, which involved targeted involvement in a single sport. Roller-hockey and soccer athletes participated in several sporting activities, but peak involvement was between 6 and 10 years of age followed by a substantial decrease. Volleyball and basketball athletes had a similar increase in involvement, but peaked later, during the orientation stage (i.e., between 11 and 14 years of age), followed by a gradual decrease. All groups showed minimal involvement in other sports after 18 years of age. Statistically significant differences were confirmed in *Number of activities practiced* between 11 and 14 years of age for roller-hockey and soccer ($z = -2.678$; $p = 0.000$) and between 15 and 18 years of age for roller-hockey and basketball ($z = -3.745$; $p = 0.001$).

The type of sports the athletes were exposed to during their long-term sports development was also analyzed. Besides participation in their main sport, roller-hockey players reported participating mainly in other team sports and individual sports with participation in these additional activities diminishing throughout their development. Volleyball athletes reported preferring team sports during initiation (28.6%) and orientation (21.4%) stages and a combination of team and individual sports (14.3%) during the second developmental stage. During the specialization stage, volleyball athletes reported an almost exclusive dedication to their main sport. Results obtained for soccer athletes demonstrated that they preferred their main sport (54.7%) (although 35.7% played a combination of several sports) during the initial stage of their long-term development and a substantial decrease in involvement in other sports during the following developmental stages. Finally, basketball athletes reported participating in a wide range of additional sports during childhood, with particular relevance to the experiences in other team sports and/or individual sports. According to the results in Table 2, involvement in different types of sporting activities continued during the orientation stage, but decreased after 15 years of age when specialization in basketball was dominant. Results revealed statistically

significant differences in *Type of activities practiced* between 15 and 18 years of age between roller-hockey and basketball ($z = -3.499$; $p = 0.001$).

Concerning weekly time spent in training activities, roller-hockey, soccer and basketball, the athletes' involvement increased quickly with almost 70% of these groups dedicating 300 or more minutes a week to training before 15 years of age. On the other hand, volleyball athletes' increase was slower, while the substantial increase in minutes per week dedicated to training was only reported after 15 years of age. Results revealed statistically significant differences in the *Average minutes of practice per week* in all stages prior to high-level performance, predominantly between volleyball and the other sports. During initiation, differences were found between volleyball and roller hockey ($z = -3.353$; $p = 0.012$) and between volleyball and soccer ($z = -2.666$; $p = 0.012$); during orientation, differences were found between volleyball and roller hockey ($z = -3.185$; $p = 0.000$), between volleyball and soccer ($z = -3.614$; $p = 0.000$) and between volleyball and basketball ($z = -3.924$; $p = 0.000$); finally during specialization stage, differences were found between volleyball and soccer ($z = -3.391$; $p = 0.000$) and between volleyball and basketball ($z = -4.462$; $p = 0.000$).

Discussion

Results from the current study contribute to our understanding of the long-term development of expert athletes in team sports. Although most athletes began sport participation between 6 and 10 years of age, there was significant variation across groups suggesting considerable flexibility in the pathways to expertise. Results within and between sports regarding the age athletes started participating in their main sport support these findings. For example, in volleyball there were athletes who began training for their main sport between 6 and 10 years of age but there were also athletes who did not begin volleyball-specific training until after 19 years of age. Indeed, volleyball and basketball athletes had the most variability in their pathways to expertise, compared to soccer and roller hockey.

Our data also indicate considerable involvement in sports other than the athlete's primary sport, suggesting early specialization is not required for these sports (similar to Baker et al., 2003). The role of early specialization in the development of sport expertise is a point of contention among researchers. While there is consistent evidence linking quantity of training with level of proficiency attained, a focus on specialized training during early stages of development has been linked with several negative consequences (Baker, 2003). Our results seem to support the notion that diversified involvement in a number of sports during early stages of development is a viable alternative to early specialization. Previous work (Baker et al. 2003; 2006) has suggested that this type of approach facilitates the development of intrinsic motivation and provides an improved atmosphere for acquiring general motor and physiological capabilities.

The type of sporting activities and contexts experienced at different stages of development could determine where sport participation will ultimately end. During childhood and early adolescence, all groups had involvement in sports other than their main sport; however, during late adolescence/early adulthood sport involvement was primarily in the main sport activities, especially in the roller-hockey and soccer athletes. These results support recent studies on the developmental histories of expert team ball sport players (e.g. Baker et al., 2003) where experts characteristically report exposure to a wide range of sports during early development (between 5 and 13 years of age). Exposure to practice in other sport settings, especially in generic aspects of pattern recognition and decision-making, may circumvent the need for, or perhaps partially substitute for, some of the many hours of sport-specific practice needed to become an expert in team sports (Abernethy et al., 2005; Baker et al., 2003). Expertise in team sports may be sufficiently multi-faceted to permit beneficial learning to occur through settings other than deliberate, task-specific practice. The activities commonly reported as early activities by the expert athletes were, in most cases, team sports that share a number of characteristics in common with the sports in which these participants became experts. For instance, all require repeated, dynamic decision-making during play and all are played in a confined space that necessitates the development of pattern recognition and spatial awareness skills. Moreover, all require a high degree of physical ability for success. Participation in varying forms of aerobic activity could provide beneficial cardiovascular effects enhancing performance in sports such as roller-hockey, volleyball, soccer and basketball, which place heavy demands on aerobic energy systems.

These findings provide important direction for future work in this area. The variability in the paths of these expert athletes reinforces the need for additional work to establish precisely what benefit is accrued from participation in sports and activities outside of one's area of adult specialization. While data continue to accumulate on the transfer of generic pattern recognition skills (e.g., Abernethy et al., 2005; Smeeton et al., 2004) and general physiological functioning (e.g., Baker et al., 2005a), future studies should expand this discussion to consider other types of skills including capabilities such as motivation for intense training, mental toughness and the development of specific occularmotor capabilities. In addition, these data extend the work of Baker, Côté and their colleagues (e.g., Côté et al., 2003), which has been largely focused on North American and Australian samples.

There were some limitations in the current study that could be improved in subsequent studies. The use of a retrospective survey may be limited with respect to the information athletes can validly recall. Although we took precautions to ensure the reliability and validity of our data, retrospective recall methods will always be limited in this regard, particularly compared with prospective longitudinal methods. Furthermore, our use of an ordinal response scale for number of activities and duration of training, is less precise than previous work (e.g., Baker et al., 2003), and although our assumption that this method would result in athletes being better able to recall general aspects of their training is reasonable, future work is necessary to determine which method (ordinal versus open-

ended) results in data that are more valid and reliable.

Conclusion

Findings from this study suggest that the pathways to sport expertise are variable, which is opposite to frameworks of development such as Ericsson's theory of deliberate practice emphasizing early specialization. There were both differences within and between sports. Most notably, the path to expertise in volleyball was clearly distinct from the paths of basketball, soccer and roller-hockey. These results add further evidence regarding the complexity of the processes underpinning skill acquisition in sport.

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Key points

- Although most athletes began sport participation between 6 and 10 years of age, there was significant variation across groups suggesting considerable flexibility in the pathways to expertise.
- The path to expertise in volleyball was clearly distinct from the paths of basketball, soccer and roller-hockey.
- There is a considerable involvement in sports other than the athlete's primary sport, suggesting early specialization is not required for these sports.
- The pattern of participation in specific and non-specific sports for each stage of involvement demonstrated an increase in the number of activities participated in until early adolescence.

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