

Early Specialization in Youth Sport: a requirement for adult expertise?

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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. Diversified involvement in a number of sports during early stages of development has been presented as a possible alternative to early specialization. Considering the consequences of advocating the early specialization approach and research suggesting the effectiveness of early diversification, coaches and sport scientists should consider the early diversification approach as an alternative. Further research is required to expand our understanding of the relative contributions of diversified versus specialized training.

The acquisition of expertise in sport is the result of complex interactions among biological, psychological, and sociological constraints (Singer & Janelle, 1999). Successful negotiation of these constraints can lead to the highest levels of performance while unsuccessful negotiation can lead to burnout and/or dropout from sport (Wiersma, 2000). One issue of contention among researchers examining expertise from a developmental perspective (e.g. Baker, Côté & Abernethy, 2003; Ericsson, Krampe & Tesch-Römer, 1993) is whether aspiring expert athletes need to limit their childhood sport participation to a single sport, with a deliberate focus on training and development in that sport (i.e. early specialization—not to be confused with recreational participation in a single sport). The opposite perspective (i.e. early diversification) favours a focus on involvement in a number of different sports before specializing in later stages of development (Wiersma, 2000). The purpose of this review is to examine the evidence both for and against the early specialization perspective and to present the early diversification approach as another path leading to elite levels of performance. As well, directions for future research are presented in order to further our understanding of the requirements of learners in the early stages of expertise.

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Evidence Supporting Early Specialization

There is a wealth of evidence supporting the early specialization approach. In a review of several decades of research on the effects of practice and training on learning, Ericsson *et al.* (1993) speculated that early specialization in what they termed “deliberate practice” (i.e. effortful practice that lacks inherent enjoyment done with the sole purpose of improving current levels of performance) was essential to the development of expertise in any domain. In their study of musicians, experts began training around 5 years of age. Ericsson *et al.* posited that if training did not begin early enough, late beginners would be unable to catch up to peers who began specialized training earlier. Much of the empirical evidence to support the conclusions presented by Ericsson *et al.* regarding early specialization centers around the *10-year rule* (Simon & Chase, 1973) and the *power law of practice* (Newell & Rosenbloom, 1981).

The 10-year Rule

In their classic study of chess expertise, Simon and Chase (1973) suggested that inter-individual variation in performance can be explained by quantity and quality of training. This hypothesis was based on findings indicating differences between the expert level (grandmaster player) and lesser levels of skill (master and novice players) was attributable to the ability to organize information in more meaningful “chunks” rather than the possession of a superior memory capacity. Since then, researchers (e.g. Starkes & Deakin, 1984) examining expert and novice differences have found no reliable distinctions on static, physical capacities such as visual acuity, reaction time, or memory (termed “hardware” by Starkes & Deakin, 1984) but consistent differences for domain-specific information-processing strategies, such as the ability to recognize structured offensive and defensive patterns (termed “software” by Starkes & Deakin, 1984). Singer and Janelle (1999) summarized the characteristics that distinguish the expert as follows:

- (1) Experts have greater task-specific knowledge (McPherson, 1993; McPherson & French, 1991).
- (1) Experts interpret greater meaning from available information (Abernethy, 1987,1990, 1991).
- (2) Experts store and access information more effectively (McPherson, 1993).
- (3) Experts can better detect and recognize structured patterns of play (Allard & Starkes, 1980; Simon & Chase, 1973).
- (4) Experts use situational probability data better (Abernethy & Russell, 1984, 1987).
- (5) Experts make decisions that are more rapid and more appropriate (Williams, 2000).

Research in sport expertise has been somewhat limited to perceptual or cognitive sports; however, existing evidence suggests that in fields where the distinguishing characteristics between experts and non-experts are domain-specific, information-processing abilities, these differences are the result of training rather than innate

abilities. While certain gross, general traits have been linked to genetic endowment (e.g. intelligence: Bouchard, 1997), the refinement of these traits into domain-specific abilities (e.g. pattern recognition, strategic thinking) is likely due to training. The idea that there is a gene that predisposes an athlete to superior information processing that is only manifested in a single domain (e.g. a gene for processing soccer-specific information) is not supported empirically.

The “10-year rule” stipulates that a 10-year commitment to high levels of training is the minimum requirement to reach the expert level. This rule has been applied successfully in many domains including music (Ericsson *et al.*, 1993; Sosniak, 1985), mathematics (Gustin, 1985), swimming (Kalinowski, 1985), distance running (Wallingford, 1975), and tennis (Monsaas, 1985). Ericsson *et al.*'s (1993) theory of deliberate practice extends Simon and Chase's work by suggesting that it was not simply training of any type, but the engagement in deliberate practice that was necessary for the attainment of expertise. In the deliberate practice framework, future experts perform training that develops required skills under continuously evolving conditions where training stress and recovery are optimally balanced so that maximal training adaptations occur and training plateaus are minimized.

The Power Law of Practice

Research examining the accumulated effects of prolonged practice and the rate of learning has robustly indicated that performance increases monotonically according to a power function. This finding, better known as the power law of practice (or the log-log linear learning law), has been demonstrated consistently in numerous domains (for a review see Newell & Rosenbloom, 1981). The power law of practice states that learning occurs at a rapid rate after the onset of practice but that this rate of learning decreases over time as practice continues. Put more simply, the more time an individual devotes to practice, the greater their level of achievement but the more difficult it becomes to make further improvements. Based on these findings, Ericsson *et al.* presented the *monotonic benefits assumption* suggesting a monotonic relationship between the number of deliberate practice hours and performance level achieved. Their research with musicians indicated that the difference between expert and non-expert pianists and violinists was due to the amount of time spent practicing alone (i.e. in deliberate practice). The best musicians had spent in excess of 10,000 hours practicing alone while their less successful counterparts had no more than 7,000 hours.

The Ericsson *et al.* (1993) research further supports the notion that proficiency is tied to time spent in practice or training; moreover, they argued that it was not simply the accumulation of deliberate practice hours over a period of 10 years that led to superior levels of performance. The accumulation of such hours must coincide with crucial periods of biological and cognitive development. Early specialization became an important element in predisposing one to future success. Based on these findings, Ericsson *et al.* concluded that the earlier one begins focused training the greater chance they have of achieving exceptionalism in their chosen domain.

Consequences of Early Specialization

Although the empirical evidence supporting early specialization is sound, there are negative consequences associated with this approach. Wiersma (2000) speculated that the limited range of skills performed during early sport specialization has the potential to limit overall motor skill development. This, in turn, may affect long-term physical activity involvement (and therefore long-term health) by decreasing the likelihood of participation in alternative physical activities.

Moreover, Wiersma (2000) suggested that early specialization could stifle sociological and psychological development by reducing the number of opportunities for growth in these areas. Sport is an excellent means of developing social skills such as cooperation and socially acceptable behaviour; however, spending too much time training may not provide enough time for social growth and can lead to “social isolation” (Wiersma, 2000). Further, excessive training without adequate recovery can lead to staleness and/or burnout (Henschen, 1998).

There are also physiological consequences to early specialization. In a review of overuse injuries in adolescents, Dalton (1992) indicated that during crucial periods of biological development excessive forms of training could have serious costs. An example of this is often seen in the knees of developing athletes. Due to rapid bone growth of the femur, tibia and/or fibula (such as occurs through a “growth spurt”) tightness and inflexibility increase around the knee joint because muscles and tendons have not increased in length at the same rate as the bones. This creates an imbalance in the joint and under periods of physical training or activity increased stress is applied to the knee and connective tissues. These imbalances increase a youth’s susceptibility to knee injury from repetitive microtrauma and associated conditions (e.g. Osgood-Schlatters’ disease or osteochondrosis).

Perhaps the most damaging evidence against advocating the early specialization approach concerns sport dropout. Investigations of participants who drop out of sport (e.g. Ewing & Seefeldt, 1996; Gould, 1987; Weiss & Petlichkoff, 1989) have consistently indicated that lack of fun or enjoyment is a predominant motive for discontinuing participation in a given sport. In a recent 10-year retrospective investigation of drop out from competitive youth sport, Butcher, Lindner, and Johns (2002) found that during early stages of involvement “lack of enjoyment” was the most important reason for transfer to a different sport or withdrawal from sport altogether. Recall that a defining characteristic of the deliberate practice activities outlined by Ericsson *et al.* is that they are not inherently enjoyable. The types of training advocated by the early specialization approach may be at odds with the level of enjoyment necessary for a long-term commitment to physical activity involvement.

Support for Early Diversification

The early specialization approach is based on the assumption that in early stages of development, deliberate practice is superior to other forms of training. Researchers examining the early stages of development in elite athletes (e.g. Côté, 1999; Hill,

1993) have indicated that early sport specialization as a child does not seem to be an essential ingredient for exceptional sport performance as an adult. Hill (1993) indicated that performing a range of activities during youth was the norm for professional baseball players while Ward, Hodges, Starkes, and Williams (2002) found that elite soccer players did not specialize until after age 16. Furthermore, Côté and colleagues found a variable sport involvement during early stages of development in elite rowing and tennis (Côté, 1999) as well as in field hockey, netball, and basketball players (Baker *et al.*, 2003; Côté, Baker & Abernethy, 2003).

In the developmental models of sport expertise presented to date, early involvement in sport comes in the form of diversified, play-like participation with little emphasis on skill development and competition (Bloom, 1985; Côté, 1999; Côté *et al.*, 2003). Côté and colleagues (Côté, 1999; Côté & Hay, 2002; Côté *et al.*, 2003) indicated that expert athletes “sampled” a wide range of sporting activities before gradually whittling down the number of activities and “investing” in one activity during mid to late adolescence. They argued that play-like involvement in a number of sports is beneficial for developing the intrinsic motivation required during later stages of development when training becomes more structured and effortful.

There is also evidence that athletes who had a diversified sport background were not at a disadvantage compared to athletes who specialized early. In a recent study of expert decision makers from the sports of basketball, netball, and field hockey, Baker *et al.* (2003) indicated that participation in other relevant activities (e.g. other sports where dynamic decision-making is necessary) during early phases of development augmented the physical and cognitive skills necessary in their primary sport. An examination of elite field hockey, rugby and water polo players by Stevenson (1990) also suggests that those who have a diversified early involvement are not disadvantaged. More interestingly, Barynina and Vaitsekhovskii’s (1992) study of elite swimmers indicated that athletes who specialized early spent less time on the national team and ended their sports careers earlier than athletes who specialized later.

Our understanding of the mechanisms by which diversification influences skill development is limited; however, it is likely linked to research examining transfer of learning and the effects of cross-training. Thorndike (1914) suggested that “identical elements” between tasks were transferable. More recently, Schmidt and Wrisberg (2000) categorized transferable elements into movement, perceptual, and conceptual elements. Movement elements refer to the biomechanical and anatomical actions required to perform a task. For example, throwing a baseball overhand and an overhand serve in tennis share movement elements. Perceptual elements refer to environmental information that individuals interpret to make performance-related decisions. For instance, field hockey and soccer both require participants to accurately interpret the actions of their opponents in order to be successful; therefore, these sports share this perceptual element. Lastly, conceptual elements refer to strategies, guidelines, and rules regarding performance. Gymnastics and diving share conceptual elements (e.g. similar rules), as do basketball and netball (e.g. similar strategies).

There is evidence that a “physical conditioning” category should be added to this list of transferable performance elements. Researchers examining the physiological effects of “cross-training” have provided support for the notion that general cardiovascular effects can be transferred (e.g. Loy, Hoffmann & Holland, 1995). Over the past two decades, exercise physiologists have spent considerable time examining the transfer of cardiovascular and peripheral training effects across similar and dissimilar modes. Typically, researchers have found that cross-training effects are more likely to occur between sports that share similar modes of activity than between dissimilar modes of activity. For example, short-term interventions of combined run–cycle training, which share similar muscle groups (i.e. similar modes), have been found to be as effective as running alone in increasing physiological parameters such as aerobic capacity (Flynn, Carroll, Hall, Bushman, Brolinson & Weideman, 1998; Mutton, Loy, Perry, Holland, Vincent & Heng, 1993) while combined run–swim training was not as effective as running alone (Foster, Hector, Welsh, Schrage, Green & Snyder, 1994). In a recent examination of transfer of training in triathletes, Millet, Candau, Barbier, Busso, Rouillon and Chatard (2002) found that cross-training effects occurred between cycling and running but not for swimming (i.e. a dissimilar mode of activity).

Increases in aerobic capacity are the result of central and peripheral adaptations to training stress (Tanaka, 1994). Central adaptations include increases in blood volume, stroke volume and maximal cardiac output while peripheral adaptations include increases in capillary density, mitochondrial density and volume, and oxidative enzyme activity. Previous research (Rowell, 1986; Saltin, Nazar, Costill, Stein & Jansson, 1976) suggests that during early stages of training changes in aerobic capacity are the result of the equal contribution of central and peripheral adaptation. In highly trained individuals, these changes are accounted for almost entirely by central adaptations leading to increased maximal stroke volume and cardiac output (Rowell, 1986). However, while these reflect central training adaptations, they are likely the result of specific peripheral adaptations such as the redirection of blood flow away from non-exercising tissues (see Sutton, 1992 for a review).

Research also suggests that the effects of cross-training and/or transfer of “identical elements” are most pronounced during early stages of involvement (Loy *et al.*, 1995; Schmidt & Wrisberg, 2000). For instance, any form of aerobic exercise can cause the gross central adaptations that occur at the onset of any physical training program; however, the more trained an athlete becomes, the smaller the relative improvement from cross-training.

Researchers examining the differences in amounts of training between experts and non-experts have indicated that significant differences do not typically occur until around 10 years into their sporting career. In their study of expert field hockey and soccer players, Helsen, Starkes, and Hodges (1998) suggested that at around 9 years of involvement future expert athletes make the decision to invest significantly more time and effort into training in order to reach the international level. Similarly, Baker *et al.* (in press) found that the amount of time that experts and non-experts spent in training was not significantly different until after 18 years of age. After this age, experts dramatically increased their commitment to training.

Future Research Directions

Collectively, these findings suggest that in certain sports early diversification may be equally useful to early specialization in the acquisition of physical skill. While this research provides evidence for the role of early diversification, our understanding is far from complete. In particular, further research is required to address shortcomings in two main areas, corroboration of previous research and laboratory-based investigations of transferable elements.

Corroboration of Previous Research

When attempting to provide an alternative to something as empirically sound as early specialization, corroboration of research findings are particularly important. Studies to date supporting the role of early diversification have typically examined team sports in decision-making environments (e.g. basketball, netball, and field hockey players in Baker *et al.*, 2003; baseball players in Hill, 1993). Future investigations should examine the role of specialized versus diversified training in other sports. Specifically, researchers need to examine whether early diversification is applicable across all forms of sport or if it is restricted to a single category of sports utilizing specific performance elements (e.g. team decision-making sports or aerobically driven sports). Moreover, Starkes, Deakin, Allard, Hodges, and Hayes (1996) indicated that elite figure skaters began training as early as 5 years of age while wrestlers began training at 13 years. It may be that in sports where peak performance occurs at a younger age (e.g. figure skating, gymnastics) early specialization is a requirement for expert-level performance. Research is required to demonstrate how applicable an early diversification approach is to sport in general.

Laboratory-based Investigations.

Experimental methods are essential to uncovering the mechanisms that influence training adaptations through diversified training. Our understanding of the performance elements that are transferable across domains and the time-span to which they are limited is not known. The addition of strictly controlled environments and manipulations of individual variables would provide required information in this area. Further, the tracking of individual performance longitudinally, although time consuming, may be necessary to understand the nature of the effects of early-diversified training. Studies are needed that examine transfer effects over longer periods than typically studied in order to identify the effects of diversified forms of training.

Future studies should also examine training structure across periods of development to better ascertain the essential components of training during early, middle and later stages. As indicated by Helsen *et al.* (1998), the period around 9 years of involvement represents a watershed in the development of sport expertise; however, more research is required to determine what needs to occur before, during, and after this period.

Conclusions

The role of this article has not been to present early diversification as a superior method of training for reaching expertise. However, diversified training in the early stages of development has been presented as an additional route leading to high levels of performance but with the following qualifications. First, the other forms of training must have similar underlying performance elements in order to be useful. Second, the effect of diversified training decreases as the level of expertise increases. While it is clear that empirical research supporting the early diversification approach is limited, research from the fields of physiology and motor learning support its validity. Considering the consequences of advocating an early specialization approach, coaches and sport scientists should consider the early diversification approach as an alternative.

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