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Developmental Trajectories in Early Sport Specialization: A Case for Early Sampling from a Physical Growth and Motor Development Perspective

Jacqueline D. Goodway and Leah E. Robinson

This commentary examines the argument for early sport specialization versus sport sampling from a physical growth and motor development perspective. Three developmental frameworks are examined (Mountain of Motor Development, Developmental Model of Sport Participation, Spirals of Engagement Trajectory model) to make the case that a broad base of fundamental motor skill competence is necessary in the early years before sport specialization in the adolescent years. Early sport specialization is criticized from the standpoint of increased risk for overuse injury, concerns about long-term growth, and the fact that early and intense practice schedules often do not differentiate elite versus nonelite athletes. A strong argument is made for early sport sampling to acquire a broad base of fundamental motor skills to apply to different sports, and to allow physical maturity to develop before specializing in sport. Such an approach also better equips a child to be active across the lifespan.

Keywords: sport diversification, fundamental motor skills, youth sport

Youth sport provides a valuable environment in which children can develop their motor and psychosocial skills, learn how to be “coached,” and become part of a team. We argue that the constructive use of youth sport should be an important part of every child’s upbringing and a medium through which key developmental processes can occur. In contrast to this idyllic view, Gould and Carson (2004) argue that youth sports have undergone professionalization that is counterproductive to healthy child development and disadvantages the majority of children who will never go on to be elite athletes. De Knop, Skirstad, Engstrom, Theeboom, and Wittock (1996) also suggest that cultures around the world are experiencing the institutionalization of youth sports. There is clearly great debate within the youth sport community about the growing trend toward early sport specialization by young children in contrast to a multisport approach to youth development.

In this paper, we consider arguments both for and against early sport specialization, taking into account the issues of motor development and physical growth. First, we define key terms and introduce developmental frameworks that offer a perspective on early sport specialization. We then review the evidence for and against early sport specialization and conclude with our stance—that a

broad base of motor skill development, which is typically learned in multisport settings, is necessary and important before sport specialization.

Definition of Terms

Before we embark on discussing the issue of early sport specialization from a physical growth and motor development perspective, it is important to define key terms. First, a *developmental perspective* is a point of view that assumes children are at different levels of development (i.e., motor, cognitive, emotional, social, and physical). Different levels of development will differentially affect children’s ability to learn and improve motor skills. Motor development is the study of changes in human motor behavior, the processes that underlie these changes, and the factors that affect these changes (Payne & Isaacs, 2014). Motor development includes the interaction of experience (e.g., practice, instruction, and appropriate equipment) with an individual’s current physical, cognitive, emotional, and social maturity (Gallahue, Ozmun, & Goodway, 2012; Williams, Payne, & Robinson, 2010). For the purposes of this review, we will refer to motor development as a set of *fundamental motor skills*—skills that require the activation of large muscles to produce movement to engage in youth sports (Haywood & Getchell, 2014). Specifically, these skills are classified as object control skills (also referred to as ball or manipulative skills) and locomotor skills (Haywood & Getchell, 2014). *Object control skills* involve

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transporting, intercepting, or projecting objects and include actions such as throwing, catching, dribbling, kicking, underhand rolling, and striking. *Locomotor skills* involve different movements to transport the body from one location to another and include running, jumping, hopping, leaping, galloping, and sliding (Ulrich, 2000). These skills are seen as building blocks for more complex and sport-specific movements (Clark & Metcalfe, 2002; Gallahue et al., 2012; Seefeldt, 1980). For example, to participate in Little League Baseball, artistic gymnastics, or tennis, basic fundamental motor skill competence in running, catching, throwing, and striking are needed.

Throughout this paper we refer to early sport specialization versus sport sampling. We use Côté, Lidor, and Hackfort's (2009) definition of *early sport specialization*, which implies a focused involvement in one sport and a large number of hours of deliberate practice with the goal of improving sport skills and performance outcomes during childhood. In contrast, *sport sampling* refers to engaging in a variety of different sports during the formative youth sport years with the ultimate goal of learning skills and having fun (Côté et al., 2009).

Developmental Frameworks Relevant to Early Sport Specialization

Ahead we review three developmental frameworks that are relevant to examining early sport specialization. The first is the Mountain of Motor Development framework (Clark & Metcalfe, 2002), the second is the Developmental Model of Sport Participation (Côté, Baker, & Abernethy, 2003, 2007; Côté & Fraser-Thomas, 2007), and the third is the Spirals of Engagement Trajectory model (Stodden et al., 2008).

Mountain of Motor Development

Clark and Metcalfe (2002) described developmental change using the metaphor of a mountain. This Mountain of Motor Development framework offers a valuable perspective in considering early sport specialization versus sport sampling in the early years. The framework recognizes the importance of both biology and environment in driving change toward skillful movement or sport performance across five phases of development (reflexive, preadapted, fundamental motor patterns, context-specific, skillfulness). At the base of the mountain are *reflexive* behaviors, which are infant responses and "primitive" reflexes (e.g., stepping, search, and sucking) necessary for survival and adaptation to a new environment. With age, infants enter the *preadapted* period when their movement behaviors are no longer reflexive, and the preadapted period ends at the onset of walking. During this period, infants attain self-feeding and basic movement skills (e.g., crawling, rolling, and walking) that form independence and often seem to develop naturally. As young children make their way up the Mountain of

Motor Development, they reach the *fundamental motor patterns* period between ages 1–7, and it is typically during the latter part of this period that children begin to enter youth sports. During the fundamental motor patterns period, children begin to acquire many building-block skills that are needed in sport, such as throwing, catching, and running. Although many believe these skills naturally develop, there is strong evidence that these skills require significant practice and instruction for skill development to occur (Goodway & Branta, 2003; Logan, Robinson, Wilson, & Lucas, 2012; Robinson, 2011; Robinson & Goodway, 2009).

Around age 7, most children transition to the *context-specific* period for some motor skills. During this stage, children refine and combine basic motor skills, such as locomotor and object control skills, to more context-specific movement patterns and begin to adapt these skills to youth sports. For example, running and jumping can now evolve into tumbling and vaulting in gymnastics, just as throwing and catching can be used in softball. With continued practice, some children reach the mountain's summit. This summit, called *skillfulness*, requires countless hours of practice and a range of internal (e.g., motivation, physical growth, strength, flexibility) and external (e.g., coaching, socioeconomic status, facilities to practice, equipment) factors that could affect skill outcomes. A feature of the Mountain of Motor Development is *compensation*. Compensation refers to adjustments in motor performance that might occur as a result of factors such as injury or loss of strength. For example, following a Little League elbow injury (e.g., medial epicondylar fracture) and during rehabilitation, a young child might find himself "down the mountain" at the context-specific period; however, with increased strength, rehabilitation, and practice, the child might be able to return to a higher peak of skillfulness.

Clark and Metcalfe (2002) suggest that children are likely to be skillful in only some context-specific skills, thus it is beneficial to characterize the Mountain of Motor Development more accurately as a mountain range with multiple mountain peaks in the developmental landscape. Each mountain peak is reflected as a context-specific sport. High peaks in the mountain range represent sports where the child is skilled and lower peaks represent sports where the child is less skilled. However, the key to going up any mountain peak (context-specific activity, such as a specific sport) is a broad base of competency in fundamental motor skills. For those children with fundamental motor skill competence, many sports (mountain peaks) are available to them, as they possess the necessary motor competence to apply their skills to a variety of sports. However, a child might be highly skilled in one sport, such as soccer (at or near a mountain's peak), but at a lower developmental level in throwing and catching, resulting in poorer performance in sports like baseball or softball.

In early sport specialization, the goal would be to climb one mountain peak as quickly as possible with the intent of developing a high degree of skill in one sport. In

this case, the mountain range would be made up of one tall mountain peak and many lower mountain peaks. We argue that early specialization in one sport limits the development of a broad movement repertoire of fundamental motor skills and thus will limit the opportunity to climb up many mountain peaks; in other words, the opportunity for a diversity of sports available across the lifespan is limited. For example, the young child that specializes in gymnastics early will not necessarily develop competence in object control skills (e.g., catching, throwing) and thus they will be less likely to find enjoyment in lifetime sports such as basketball, softball, and tennis. However, children who sample multiple sports in the early years are more likely to develop competence in the type of object control and locomotor skills that make up many different sports. We suggest that sport samplers, who have had the opportunity to develop essential fundamental motor skills, will have many different sports available to them across the lifespan (i.e., they will have the ability to travel up many different mountain peaks to find enjoyment). Thus, we suggest that sport sampling in the formative years is superior to early specialization.

Developmental Model of Sport Participation

Côté and colleagues (Côté, 1999; Côté et al., 2003, 2007; Côté & Fraser-Thomas, 2007) provide another way to examine the developmental trajectory of youth sport participation through the Developmental Model of Sport Participation. The initial work in this area was founded on an in-depth qualitative study of four families with elite athletes in rowing and tennis. Côté couched this work with respect to the extent of deliberate play and deliberate practice (Côté & Hay, 2002; Ericsson, Krampe, & Tesch-Römer, 1993). Deliberate practice is defined as highly-structured activity that requires physical and/or cognitive effort with no immediate rewards, where the intent of the activity is improving performance rather than just enjoying the activity (Ericsson et al., 1993). In contrast, deliberate play is described as engaging in an activity primarily for intrinsic enjoyment, although the activity may still contribute to skill learning (Côté et al., 2007).

Côté and Fraser-Thomas (2007) propose three distinct pathways (trajectories) into youth sport participation, which include: (1) participating in a *sampling* of recreational sport participation through deliberate play, (2) later *specialization* in elite sport performance through *early sampling* of a variety of sport activities that involve deliberate play, or (3) elite performance in sport through *early sport specialization* and deliberate practice. The differences between these developmental trajectories lie within the types and amount of involvement in sport, deliberate play, and deliberate practice.

The first two trajectories into youth sport (1 and 2 above) involve an *early sampling approach* during the formative years where the child engages in a broad base of sport activities focused on deliberate play (Côté &

Fraser-Thomas, 2007). Parents provide the lead to enable their child's sport participation and encourage children to engage in many different sports with the overall goal of "fun and excitement through sport" (Côté, 1999, p. 401). The sport itself is not as important as the child engaging in sport as an important part of his/her overall development. During the sampling phase, children engage in more deliberate play and less deliberate practice (Côté, 1999; Côté & Fraser-Thomas, 2007). These sampling years typically occur between the ages of 6 and 12.

Côté and colleagues' Developmental Model of Sport Participation aligns nicely with the Mountain of Motor Development (Clark & Metcalfe, 2002). It is during the age range of 6–12 years that children are developing competence in fundamental motor skills and beginning to combine these fundamental motor skills in a variety of sports and games. The goal during these sampling years is the acquisition of proficient performance in fundamental motor skills, the development of high perceptions of competence, and engagement in a diversity of sports so that children can begin to determine the next pathway in their youth sport trajectory. Côté suggests that, regardless of whether a child stays at the recreational level or goes on to be an elite performer, this sampling phase is a critical stage of development in which all children should engage (Côté, 1999; Côté & Fraser-Thomas, 2007).

Around the age of 13–15 years, children's developmental trajectories face a fork in the road. At this time, they can either (a) stay involved in recreational sports or (b) shift to specializing in one sport. Positive experiences with a coach, encouragement from siblings/friends, success in the sport activity, and/or the sheer joy of participating provide the direction that drives a child to select one sport activity over another in which to specialize (Côté, 1999). This phase is marked by increasing deliberate practice and decreasing deliberate play within one sport, as well as decreasing involvement in other activities (Côté, 1999). While fun and excitement are still important parts of the sporting experience, the development of sport-specific skill through sustained deliberate practice is central to this phase (Côté, 1999). Parents become enthusiastic supporters of their child's sport specialization and must begin to commit family resources in terms of finances and time (Côté, 1999). It is during this specializing phase that children are beginning to climb one peak of the Mountain of Motor Development with the goal of improving their proficiency in a single context-specific sport in order to acquire skillfulness at the summit of the mountain (Clark & Metcalfe, 2002). Although the outcomes of Côté's two trajectories (i.e., sampling through deliberate play and later specialization through early sampling) are different (one leading to recreation and the other to elite sport), it is important to note the initial sport sampling period may produce similar positive psychosocial and physical health benefits (Côté & Fraser-Thomas, 2007).

Côté and Fraser-Thomas (2007) distinguish the third possible trajectory (i.e., elite sport performance through early specialization and deliberate practice) as different

from the other two trajectories (for a more detailed description, see Figure 8.2 in Côté et al., 2007, p. 197). Côté and colleagues suggest this *investment phase* is where a child must engage in large quantities of sustained and often intense deliberate practice, where the focus is no longer on fun but on the enhancement of sport skills, strategic knowledge, and competitive success (Côté, 1999; Côté et al., 2003, 2007; Côté & Fraser-Thomas, 2007). In this phase, parents and families often make many sacrifices for their elite child athlete to participate at such a high level. Although Côté (1999) proposes that this phase typically occurs around 15+ years, he did caution that the age of entry into the investment phase would depend on the sport. For example, in a sport such as gymnastics or figure skating, the investment phase might occur at much younger ages. Regardless of the age of entry into the investment phase, most children progress through the three phases of youth sport development by spending about three years in the sampling phase and at least one year in the specialization phase before moving into the investment phase (Côté et al., 2003, 2007; Côté & Fraser-Thomas, 2007). There is considerable evidence that young athletes from many different sports follow one of these three trajectories into sport participation (Baker, Côté, & Deakin, 2005; Baker, Robertson-Wilson, & Sedgwick, 2003; Bloom, 1985; Carlson, 1988; Côté, 1999; Soberlak & Côté, 2003).

Overall, the Developmental Model of Sport Participation provides a valuable framework to examine different developmental trajectories in youth sport participation. As suggested by this model, sport sampling in the elementary school years seems to provide the best options for a child to either continue recreational engagement in sport or enter the elite sport arena (Côté & Fraser-Thomas, 2007). Both the Mountain of Motor Development and the Developmental Model of Sport Participation imply that physical education teachers, coaches, and parents need to ensure that children learn a broad base of fundamental motor skills so they possess the necessary sport skills to stay motivated to continue sport at either an elite or recreational level across the lifespan.

Spirals of Engagement Trajectory Model

Stodden and colleagues (2008) propose a conceptual model that highlights the relationship between motor competence and physical activity. In this model, early physical activity experiences provide children with the opportunity to develop motor competence. Thus, sport samplers who have a wider range of physical activity experiences will be more likely to develop competence in a broad range of fundamental motor skills. Over time, children who are competent in fundamental motor skills will choose to engage in more physical activity, and thus further improve their motor competence. This will lead them into a positive spiral of engagement, with better health-related outcomes than children with low competence, including better fitness, healthier weight,

and positive self-perceptions about their physical ability. In contrast, children with low motor competence will be drawn into a negative spiral of disengagement, ultimately resulting in a child dropping out of physical activity and being more likely to be overweight (Stodden et al., 2008). Stodden et al. (2008) further hypothesize that the relationship between fundamental motor skills and physical activity is strengthened during the middle childhood years and continues to strengthen in adolescence and adulthood.

Recent findings from two narrative reviews provide data to support Stodden and colleagues' (2008) conceptual model. First, Robinson et al. (2015) reported that fundamental motor skill competence and physical activity are related during the early childhood years, and the strength of the associations between fundamental motor skill competence and components of fitness (i.e., cardiorespiratory endurance, muscular strength, and muscular endurance) increase with age from childhood to adolescence. The second review (Logan, Webster, Getchell, Pfeiffer, & Robinson, in press) provides support for the Spirals of Engagement Trajectory model, suggesting that, across age ranges, fundamental motor skill competence was related to physical activity for boys and girls. Finally, another study suggested that positive spirals of engagement may carry into the adult years, with youth sport participation being tied to adult physical activity (Tammelin, Näyhä, Hills, & Järvelin, 2003). Tammelin and colleagues noted that 40% of boys who participated in youth sport during adolescence still participated in recreational sport at the age of 31. What is not clear from this model is whether both sport samplers and sport specialists are drawn into positive spirals of engagement, or if the limited repertoire of sport skills by the sport specialists limits this group's engagement in physical activity later in life.

Early Sport Specialization

Early sport specialization is underpinned by the notion that specializing in one sport early in life is superior to engaging in a variety of sports during childhood (Côté et al., 2009). During early sport specialization there is a focus on skill development in a single sport and selection of the most "talented" children. The assumption during early specialization is that children should participate in high levels of deliberate practice, typically in an environment with enhanced resources, such as knowledgeable coaches or good sporting facilities (Côté et al., 2009). Côté, Baker, and Abernethy (2007) suggest there are two assumptions that form the basis of early sport specialization. The first is that early specialization results in more deliberate skill practice, which will ultimately lead to a higher skill level and elite performance in the later adolescent and adult years. The second assumption is that future experts can be differentiated from nonexperts by the quantity and quality of their deliberate practice (Côté et al., 2007). Next, we examine these assumptions

and describe the benefits and downsides to early sport specialization versus early sport sampling.

Benefits of Early Sport Specialization

Based on the developmental models presented, we contend that sport sampling is more appropriate and desirable than early specialization. However, we do acknowledge there are several benefits to early specialization in sport. We will focus on those most relevant to motor development.

Early Deliberate Practice Contributes to Greater Sport Performance. Early sport specialization can result in greater sport achievement at an earlier age. Ericsson and Charness (1994) suggest that it takes at least 10,000 hr of practice to become an expert in any skill. It is also suggested that "...the higher the level of attained elite performance, the earlier the age of first exposure as well as the age of starting deliberate practice" (Ericsson et al., 1993, p. 389). This notion is also supported by the relationship between practice and achievement, which follows the power law of practice (Newell & Rosenbloom, 1981). This law suggests a positive relationship between practice and achievement, where there is a sharp increase in initial achievement but, over time, these increases plateau and become more difficult to sustain. However, other research has countered this idea. Ericsson et al. (1993) produced a seminal paper suggesting the most important factor for sport achievement was the time spent in deliberate practice. Achievement of a specific sport performance goal is the outcome of deliberate practice. Ericsson et al. (1993) propose the relationship between practice and achievement was more linear rather than the power function described above. They postulated that the difference among performers of different skill levels could be attributed to the time spent in deliberate practice and provided data from violinists as evidence for this view. Expert violinists accrued more than 7,400 hr of deliberate practice by 18 years of age as compared with only 3,400 hr for lower-level performers (Ericsson et al., 1993).

Ward, Hodges, Williams, and Starkes (2004) examined the contribution of organized practice, play, and other activities in the development of young elite and subelite soccer players. They suggested play and involvement in non-sport-specific activities did not discriminate between players' skill levels, however, the amount of organized practice did. Ward and colleagues assert that early sport specialization with sole involvement in deliberate practice during preadolescence was the most effective path toward the development of elite performance in soccer. In addition, from a developmental standpoint, it appears that a majority of the deliberate practice was accumulated before the age of 15 (Soberlak & Côté, 2003). Early sport specialization was also found in elite rhythmic gymnasts after comparing Olympic and international groups (Law, Côté, & Ericsson, 2008). Both groups were involved in few nongymnastics activities throughout their develop-

ment. However, accumulated hours of gymnastics training (including ballet, technique, routine, and conditioning) at age 16 was significantly higher for the Olympic group than for the international group. Similar findings were found for elite rhythmic gymnasts who engaged in longer hours of practice at younger ages than a subelite group of gymnasts (Law et al., 2008). Overall, these studies suggest that early sport specialization may be necessary for athletes to acquire the hours of deliberate practice needed for elite sport participation.

Early Sport Specialization is Required for Sports With Early Peak Performance. Early sport specialization might be especially necessary for sports that require peak performance to occur earlier in the developmental window (i.e., before puberty). Evidence on differences in training and practice between elite and nonelite athletes appears as early as 7 years of age (Ward et al., 2004). Specifically, in sports where peak performance occurs at early ages (i.e., before biological maturation), such as in women's gymnastics (Law et al., 2008) and women's figure skating (Deakin & Cobley, 2003), early specialization is necessary to accumulate the hours of deliberate practice needed to reach the elite level (Côté et al., 2007). Ericsson and colleagues (1993) suggest that it would be next to impossible for a late starter to overcome the early advantage of those who begin deliberate practice at a young age and maintain high amounts of deliberate practice hours over time. However, this approach does not consider important variables such as motivation and social influences on sustaining sport participation, nor does it take into account that only a few youth athletes ever reach the highest levels of sport.

Summary of Benefits. Overall, there are some benefits associated with early sport specialization in children and youth. We can say that early sport specialization does call for early deliberate practice, which is beneficial from a sport performance standpoint. Early specialization is critical for sports where peak performance is often achieved before puberty. Gymnastics for girls and women is a prime example. Because the Olympics occur every four years, the timing of puberty and early sport specialization is key. Coaches will want any Olympic athlete to hit their peak athletic performance at the start of the Olympic year. However, for a female gymnast, the onset of puberty is one developmental factor to be considered, as it would adversely affect performance. Of course, in terms of future research, one question remains: How late is too late or how early is too early? It is unclear what the tipping point is for early sport specialization. Is there a certain age to start participating in early sport specialization? Lastly, the long-term health benefits and behaviors of children who participate in early sport specialization are unclear. Current data support the long-term health benefits of general youth sport participation (Kjønniksen, Anderssen, & Wold, 2009; Merkel, 2013). However, no data exist regarding health benefits of early sport specialization. Future research should address this issue.

Downsides to Early Sport Specialization

Despite the fact that many children specialize in one sport at early ages, and there is a common belief such early specialization is necessary to be an elite athlete, there are many downsides to early sport specialization. We raise four major developmental points and provide evidence to support these points, which counter support for early sport specialization.

Deliberate Practice Schedules Do Not Predict Later Elite Athletic Attainment. One of the premises underlying early specialization in sport is that such a trajectory will allow the early sport specialist to engage in the necessary amount of training to reach the elite levels of his/her sport. Ericsson et al. (1993) suggested that youth athletes who start specializing at older ages could never be competitive with those who specialized from early ages. Sport is replete with athlete superstars in a wide variety of sports, such as Tiger Woods (golf), Venus and Serena Williams (tennis), Tara Lipinski (figure skating), Carly Patterson (gymnastics), and Kobe Bryant (basketball), who started sport specialization and intense training in the early childhood years. However, despite these success stories we contend that the scientific evidence, though scant, does not suggest elite level performance is reliably predicted from early specialization in sport.

If the goal of early specialization is elite adult performance, the data on prediction of elite performance from childhood is not strong. In a review of talent detection and development, Régnier, Salmela, and Russell (1993) concluded that consistent and long-term prediction of talented athletes is highly unreliable, especially when detection of talent is attempted during the prepubescent or pubertal periods of growth. The research on differing practice schedules between elite and subelite athletes also does not demonstrate differences between these levels until much later in development, typically not until the adolescent years (Côté et al., 2007; Côté et al., 2009). This finding has been found for a number of sports.

Hodges and Starkes (1996) found that differences in practice and training schedules between elite and nonelite wrestlers did not occur until approximately 18 years of age. In soccer, these differences between expert and nonexpert players were reported as early as 13 years of age (Helsen, Starkes, & Hodges, 1998; Helsen, van Winckel, & Williams, 2005). Similar findings were found with elite level field hockey players, showing little difference in training schedules versus nonelite players until the age of 15 (Helsen et al., 1998). However, in a later developing sport, such as the triathlon and long distance running, training differences between elite and nonelite runners did not manifest until 20 years of age (Baker et al., 2005). Before these ages, the elite and nonelite youth athletes demonstrated remarkably similar training schedules. Other work on Dutch field hockey players cautions the reader in using practice hours to distinguish between elite and nonelite players, suggesting that sport-specific practice hours may not be sufficient to discriminate

between different levels of performance in sport (Van Rossum, 2000).

The conclusion we draw from this research is that if the goal is elite athletic performance, the intense and deliberate practice that results from early specialization is not necessarily a reliable trajectory into elite sport. We endorse the Developmental Model of Sport Participation proposed by Côté and colleagues (Côté, 1999; Côté et al., 2003, 2007). This model offers an alternative pathway into elite sport—a pathway where athletes engage in a variety of sports in the sampling years (ages 6–13) before going on to specialize in the later adolescent years. We acknowledge that this approach may not work for all sports and, as indicated earlier, that with sports where peak performance occurs early, such as in gymnastics, early sport specialization may be necessary. We have much to learn about the developmental pathways into elite sport and prospective, rather than retrospective, studies are needed.

Early Specializers Have a Greater Risk of Acute and Overuse Sport Injury.

A major developmental concern in early sport specialization is the issue of youth sport injury. We suggest that children who specialize early and engage in more deliberate and intense practice have a greater risk of acute and overuse sport injury. Sport-related injury is the leading cause of injury among school-aged children (Luke et al., 2011). It has been estimated that over 2.6 million children and adolescents are injured each year and require emergency room treatment due to sport involvement (Burt & Overpeck, 2001). Sport injuries not only exact a personal toll, but the cost of these injuries is estimated to be \$1.8 billion (Adirim & Cheng, 2003). Thus, injury in sport is a major problem. Sport injuries can be broken down into acute and chronic injuries. Acute injuries are the result of a single incident, such as a fall or a direct hit or trauma. In contrast, chronic or overuse injuries occur as a result of repetitive trauma (often microtrauma) from ongoing submaximal loading of bones, muscles, and tendons that are beyond what the child's body can handle in terms of positive adaptation (Brenner, 2007; Latz, 2005). Although youth sports in general are identified as being responsible for sport injuries, a closer examination of the data suggests that the risk of injury is not equally distributed across sports and, most importantly, across levels of sport participation (DiFiori et al., 2014; Luke et al., 2011; Purvis & Burke, 2001). Children who specialize early in one sport and engage in more hours of intense training (deliberate practice) are at a much greater risk of injury than children who engage in recreational sport (Brenner, 2007; DiFiori et al., 2014; Emery, 2003; Kalth & Mikesky, 2010).

Emery (2003) conducted a review of 46 sport injury studies and reported a number of important trends. Higher rates of injury were found in specific sports and these varied according to sex. For boys, the highest rates of injury were found in hockey, basketball, and football, and for girls, the highest rates were in gymnastics, basketball, and soccer (Emery, 2003). Risk of injury increased with

age in all sports, with adolescents over the age of 13 at a greater risk for injury than younger children. Risk of injury also increased with increasing skill level, in competition versus practice, and at higher competitive levels such as tournament play (for a detailed review of these studies, see Emery, 2003).

What we can abstract from these data is that sport injury is more prevalent in children who specialize early, who have higher demands of practice and competitive play, and who are still engaging in sport at older ages (DiFiori et al., 2014; Emery 2003). In contrast, children who engage in a sampling approach to youth sport tend to have less deliberate and intense practice, limited competition, and tend to be younger (as many quit sport by the middle school years). Thus, sport samplers are much less likely to be injured than sport specialists.

From a developmental perspective, one of the greatest concerns is the growing incidence of overuse injuries found in children and adolescents (DiFiori et al., 2014; Luke et al., 2011). A number of factors associated with early sport specialization contribute to the incidence and severity of overuse injuries. High-intensity exercise associated with training and competition is a major contributor to overuse injuries (Brenner, 2007; Bergeron, 2009; DiFiori et al., 2014; Luke et al., 2011). Other factors include extended playing seasons, inappropriate technique for skills, and competitive demands that are not in line with a child's developmental status, as well as lack of sleep and inadequate nutrition (Bean, Fortier, Post, & Chima, 2014; Brenner, 2007; DiFiori et al., 2014; Luke et al., 2011). Luke and colleagues (2011) view overscheduling the youth athlete with little time for recovery between bouts of exercise and competition as predominant reasons for overuse injuries. DiFiori and colleagues (2014) also suggest that intrinsic factors such as the adolescent growth spurt, the susceptibility of growth plates, previous injury, and levels of conditioning, as well as extrinsic factors such as training workloads, competition schedules, and inadequate equipment and skill technique are major risk factors for overuse injuries.

If we examine this issue from Côté and colleagues' view of early sampling (Côté et al., 2003, 2007), one might suggest that children will be less prone to injury if they engage in a variety of sports and have more deliberate play and less time and intensity of deliberate practice. Such children play and practice for enjoyment and within the limits of physical tolerance and thus are less likely to have overuse injuries (Luke et al., 2011). In contrast, youth in the specialization and investment phases of youth sport are often exposed to adult-like training and competitive schedules, and expectations to push themselves for performance outcomes without adequate recovery time between training and competition (Bean et al., 2014; DiFiori et al., 2014; Luke et al., 2011). In addition, early specialists often lack the physical and cognitive maturity to cope with such intense training (Bean et al., 2014; Bergeron, 2009; Brenner, 2007; Luke et al., 2011). Intense training, often with prepubertal bodies and immature cognitive development, can significantly

increase the risks of injury, as young children rely on adults to make appropriate decisions for them and lack the ability to determine an appropriate level of training for a growing body (Bean et al., 2014; Bergeron, 2009; Brenner, 2007; Luke et al., 2011).

A subgroup of overuse injuries in the young athlete that can have devastating implications into adulthood are growth plate injuries (Caine, DiFiori, & Maffulli, 2006). Although the literature has not specifically addressed the role of early specialization in growth plate injuries, it has suggested that greater amounts and intensities of training pose greater risks for growth plate injuries (Caine et al., 2006). As such, one can infer that early specialists are more at risk for a growth plate injury than samplers. Caine et al. (2006) provide an excellent overview of these injuries in the youth athlete. They suggest there are two "physis" related areas of concern. Apophyses are at the sites of major tendon attachments to bone and are vulnerable to tensile forces. For example, the patella tendon inserts into the tibial tubercle (top of the shin). In this case, the constant contraction of powerful quadriceps, such as in elite youth soccer players, may disrupt the insertion into the tibia, resulting in Osgood-Schlatter disease (bumps are observable on the top of the shin), an overuse injury that affects many young elite athletes. Although such apophyseal growth injury does not impact the long-term growth of long bones, it is very painful and often results in time away from sport or withdraw from sport (Caine et al., 2006).

The other kind of growth plate injury is damage to the epiphyseal plate (growth plate). The epiphyseal growth plate is the part of the long bone from which growth occurs and is less resilient than the bone itself. Caine et al. (2006) suggest that tolerance of this growth plate may be exceeded by the mechanical stresses of sports such as football or hockey, or the repetitive trauma of sports such as baseball, gymnastics, and long distance running (Caine, 2003; Caine et al., 2006; DiFiori et al., 2014). Such growth plate injuries not only threaten ongoing participation in sport, but they can also have significant long-term implications resulting in discrepancies to the length of bones that are damaged, angular deformity, and altered joint mechanics leading to long-term disability. Children who engage in early sport specialization are particularly vulnerable to epiphyseal growth plate injuries, as intense training can impact the maturation of their growth plates (Bean et al., 2014; Caine et al., 2006; DiFiori et al., 2014).

The final area of youth injury that has recently gained significant media attention is that of concussion. It is not within the auspices of this paper to examine the literature on concussion but it would suffice to say concussion presents a considerable long-term risk to the youth athlete. Youth football and hockey have particularly high rates of concussion (Bean et al., 2014). The frequency of sport concussion-related injuries is high, with an estimated 3.8 million concussions per year in the United States (Stein & Meehan, 2014). To further the concern about concussions, it is suggested that youth require longer recovery

from concussion than adults (Bean et al., 2014) and many governing bodies in sport are beginning to impose more stringent return-to-play policies after a concussion (for a detailed account of sport-related concussions from a pediatric perspective, see Valovich McLeod, Houston, & Welch, 2015).

Overall, there is a general consensus that early sport specialization dramatically increases the risk of injury to the young athlete and that these risks are increasingly greater with higher intensity sport training and performance (Bean et al., 2014; DiFiori et al., 2014). We suggest that these data provide strong evidence that early sport specialization is less desirable than a sampling approach to youth sport. Jayanthi, Pinkham, Dugas, Patrick, and LaBella (2013) support this view, suggesting that while some degree of sport specialization is necessary for elite-level sport, intense training in a single sport should be postponed until later adolescence when youth possess the necessary skills and developmental characteristics to optimize success and minimize injury.

Early Specializers May Not Achieve Full Adult Growth Potential. Another major developmental concern for early youth sport specialization ties to physical growth. It has been suggested that the intense training of early specialization may present a threat to the attainment of full adult stature (Malina, 1994; Rogol, Clark, & Roemmich, 2000). The literature in this area is mixed and much of it has been conducted on elite level gymnasts. One study of gymnasts, swimmers, and tennis players concluded that elite athletic performance did not impact final adult stature (Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones 2008). In addition, Malina and colleagues (1997) examined the results of three longitudinal studies of active and inactive youth in sports and found that regular sport training during puberty did not influence size attained in adulthood, growth rate, or the timing of somatic, sexual, and skeletal maturation. However, it was not clear from this work whether the sport-active youth had specialized early in sport and how intense their training schedules were.

A number of studies suggest that intense training negatively influences growth variables (Benardot & Czerwinski, 1991; Malina, 1994; Theintz, Howald, Weiss, & Sizonenko, 1993). Theintz et al. (1993) reported that elite level gymnasts did not go through the typical adolescent growth spurt in the lower extremities, which compromised their final adult stature. Thus intense training early in gymnastics did affect adult stature. In a comparison of adolescent gymnasts and swimmers over a two-year period, Theintz et al. (1993) reported that gymnasts had significantly lower growth velocities and their growth percentiles dropped over time, resulting in predicted height dropping over time. Swimmers did not demonstrate any negative impact on their growth. In addition, Lindholm, Hagenfeldt, and Ringertz (1994) observed slower growth velocities in female gymnasts as compared with a control group of inactive girls. For 27% of these elite level gymnasts, adult height was less than predicted. Benardot and Czerwinski (1991) also studied

gymnasts and found similar decrements to height and a decrease in height percentiles across time.

While there is some evidence to suggest some sports like gymnastics may impact final stature and other growth-related variables, we still have much to learn about many other sports. We also need to understand the interaction of training intensity with other intrinsic and extrinsic factors that might influence growth variables. Prospective studies are needed that examine both sport specializers and sport samplers.

Overall, studies in this section demonstrate that early sport specialization does not provide strong evidence for a developmental trajectory into elite sport. However, by specializing early young athletes place themselves at greater risk for sport injuries, some of which can have life-long effects on their physical health. Early specialization fails to acknowledge important developmental and motivational assets acquired from involvement in sport sampling (Côté et al., 2007). Tie this to the empirical support that early specialization is associated with higher levels of attrition and burnout at all levels of ability (Gould, 1987; Gould, Udry, Tuffey, & Loehr, 1996), and a stronger case can be made for early sport sampling. Sampling a wide variety of sports in the formative childhood years gives the child time to determine what pathway she/he wishes to take (recreational or elite sport) and gives the body time to mature and develop without insult.

Early Sport Specialization Does Not Necessarily Transfer into Lifelong Physical Activity Patterns. The final area we would like to address is whether youth who have engaged in extensive sport experiences as part of early specialization continue to engage in sport across the lifespan and lead a physically active lifestyle. We suggest that it is unclear if early sport specialization leads to lifelong participation in physical activity. Most of the literature focuses on youth sport rather than early sport specialization. A 10-year longitudinal study that followed 630 adolescents until age 23 (Kjønniksen et al., 2009) showed that participation in organized youth sport during childhood and adolescence was positively related to frequency of leisure-time physical activity in young adulthood. Joining an organized youth sport at an early age and continuing through adolescence appears to increase the likelihood for a physically active lifestyle in young adulthood. Others have investigated recreational outcomes from youth sport participation. Specifically, Robertson-Wilson, Baker, Derbyshire, and Côté (2003) conducted a retrospective study of adult females and found that active females participated in significantly more physical activities from ages 6–18 than inactive females. During the early and middle childhood years (ages 6–12), the active females participated in a variety of sports that were more recreational in nature and focused on deliberate play. These years are essential for the development of basic fundamental motor skills that contribute to sustained participation in recreation and sports, as suggested by Stodden and colleagues' (2008) model.

More studies are needed to examine the tracking of physical activity from childhood into adulthood for

children who specialized early in sport versus those who engaged in sport sampling. There is a need to examine the long-term effects of both youth sport participation and early sport specialization on recreational and physical activity engagement later in life. The few studies that have been conducted in this area can be criticized from a measurement standpoint, as they used retrospective questionnaires to collect data. Future researchers also need to utilize more objective-based assessments of physical activity, such as accelerometers, and conduct studies that are both prospective and longitudinal.

Conclusions: The Case for Early Sampling in Sport

Throughout the early part of this paper we made a case for children to sample a broad range of sports in the formative years as opposed to specializing early in sport. If one considers our position—that the constructive use of youth sport should be an important part of every child’s upbringing and a medium through which key developmental processes can occur—from a growth and motor development perspective, we contend that developing motor competence in a broad range of fundamental motor skills is key to a positive developmental trajectory. Although sport specialization can have some benefits, the risks associated with injury and long-term growth, the high rates of burnout, and the fact that early and intense practice schedules do not differentiate elite versus nonelite athletes provides evidence to support our tenant that *a broad base of fundamental motor skill development that is learned through sport sampling is necessary and important before sport specialization*. Thus, sport sampling in the formative youth years is clearly superior to early sport specialization.

Our goal in youth sport should be to develop a broad mountain range where children have a strong foundation of fundamental motor skills that serve as the basecamp of the Mountain of Motor Development (Clark & Metcalfe, 2002). If children develop fundamental motor skill competence through sport sampling, they will be able to apply these fundamental motor skills to many physical activities later in life (Clark & Metcalfe, 2002) and will be knowledgeable and motivated to do so (Côté et al., 2009). Such fundamental motor skill competence will allow children and youth to travel up different mountain peaks (different context-specific sport activities) with the goal of finding some degree of skillfulness in a number of activities that allow youth to be engaged and intrinsically motivated by these activities. By equipping our youth with such a developmental landscape (many mountain peaks), we will better serve them throughout their lifespan as their interests in sports change alongside changes in growth and motor development. A broad developmental landscape will also allow for individual trajectories that will have the most positive outcomes for children and youth.

Stodden and colleagues (2008) support this view, suggesting that fundamental motor skill competence is a

key underlying factor driving physical activity behaviors across the lifespan. Specifically, children who have low motor competence will most likely have poor perceived competence and thus will be less physically active. Ultimately, the interaction of these factors will impact health-related fitness and draw children into a less than desirable developmental trajectory called a negative spiral of disengagement from sport and physical activity.

We believe that the idea of fundamental motor skill competence as a key determinant of sport participation (whether recreational or elite) is missing from the youth sport literature. These important skills must be taught and reinforced in the early childhood years, as suggested by the three developmental frameworks (Clark & Metcalfe, 2002; Côté et al., 2003, 2007; Stodden et al., 2008). Further, an early sampling approach to sport provides the best opportunities to develop fundamental motor skill competence.

Our work suggests that young children who do not have opportunities to be instructed in fundamental motor skills in the early childhood years (such as those from economically-disadvantaged environments) are developmentally delayed in these skills by the preschool years (Goodway & Branta, 2003; Goodway, Robinson & Crowe, 2010; Robinson, 2011; Robinson & Goodway, 2009). Delays in fundamental motor skills in early childhood are problematic, particularly because there are many barriers to engaging in sport and physical activity in disadvantaged communities (Goodway & Smith, 2005). Children with low motor competence are quickly drawn into a negative spiral of disengagement (Stodden et al., 2008) and on a developmental trajectory to limited sport involvement and physical activity (Goodway et al., 2010). Fundamental motor skill interventions demonstrate positive changes in the motor competence of young disadvantaged children, remediating their developmental delays and enhancing perceptions of motor competence (Goodway & Branta, 2003; Goodway et al., 2010; Robinson, 2011; Robinson & Goodway, 2009; Robinson, Rudisill & Goodway, 2009). As a result of this work, we propose a precursor to the phases of the Developmental Model of Sport Participation, where children must first develop competence in fundamental motor skills before the sport sampling phase. By developing fundamental motor skill competence during the early childhood years, children can successfully apply their fundamental motor skills to a variety of sport settings across the lifespan.

Recommendations

Based on the motor development and physical growth arguments for adopting early sport sampling, we propose a developmental trajectory approach to youth sport using the following time frames and strategies:

- Early childhood years (ages 3–7): Developing fundamental motor skill competence through broad-based instructional motor skill programs (not sport-specific) to enable each child to develop enough motor competence that, when they apply them to sport,

they will be successful in the motor component of the sport (e.g., proficient hand catcher who can catch balls of different sizes).

- Upper elementary years (ages 7–11): Sampling many sports and further refining fundamental motor skills by encouraging children to apply their fundamental motor skill competence.
- Middle school years (ages 11–13): Continuing sport sampling leading into one of two trajectories: more deliberate practice of sport specialization or ongoing sport sampling and development of skillfulness in enjoyable lifetime physical activities.
- High school years (ages 14–18): Providing opportunities to engage in sport that meet the needs of different trajectories, either an array of different recreational sports that youth choose or opportunities to enhance skillfulness through specialization and investment.

In conclusion, applying this developmental trajectory approach from a physical growth and motor development perspective to youth sport means that we must maximize participation, minimize dropout, and provide children and youth with individual pathways tailored to a child's developmental needs and interests. We must develop fundamental motor skill competence in early childhood, subsequently providing a range of sporting activities throughout childhood and into adolescence. Through the adolescent years, we must increasingly provide choice to our adolescents to select the pathway (recreational or elite) and activities that are intrinsically pleasurable and keep our youth motivated and engaged in youth sport inside and outside of school. It is our hope that by developing fundamental motor skill competence and highlighting sport sampling in the formative years we will increase the number of children, youth, and adults who persist in sporting activities across the lifespan.

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