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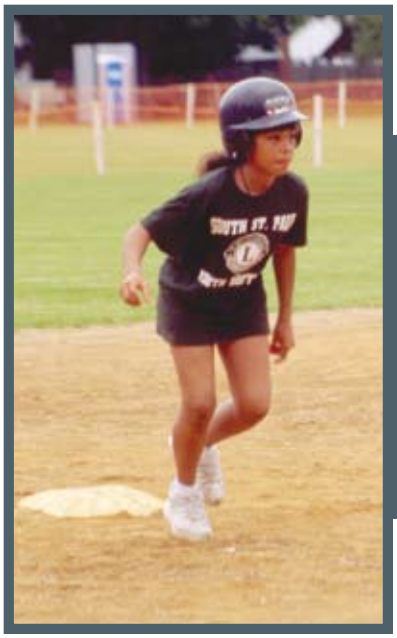

Impact of Early Sport Specialization: A Physiological Perspective

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From a physiological standpoint, the benefits of early specialization are unsubstantiated.

Participation in physical activity and sports is highly encouraged for children and can provide numerous physical, psychosocial, and health benefits. In addition to developing sport-specific skills, sport participation can also foster the growth of other life skills such as leadership, teamwork, and character (Baron, 2007; Weiss, 2004), and can have a positive effect on health-related measures later in life (Van Langendonck et al., 2003). The number of boys and girls participating in competitive athletics has increased each year for the past 20 years (National Federation of State High School Associations, 2010); however, in recent years a growing number of young athletes are concentrating on a single sport at an early age for the primary purpose of achieving future athletic success. Nowadays, it is common to see young athletes practicing three to four hours a day, five to seven days a week, while also participating in games and tournaments on the weekends. Commonly referred to as *sport specialization*, this practice typically involves children (ages 6 to 12) who commit almost exclusively to a single sport, train and compete year-round, and have high internal—and often external—expectations.

Unfortunately, some young athletes' reasons for pursuing early sport specialization are unfounded, particularly given the lack of scientific evidence to support its effectiveness. In addition to the heightened media coverage of highly successful athletes who specialized early (e.g., Tiger Woods, Amanda Beard, Tara Lipinski, Serena and Venus Williams), several other factors likely have a powerful influence in the decision-making process—most notably parents, coaches, and other athletes (i.e., peers). The allure of obtaining an athletic scholarship is particularly motivating to parents and athletes and may be perceived as the only means for some individuals to get a college education. Furthermore, many coaches recommend that young athletes participate in a single sport year-round, often through participation in "out of season" camps, clinics, or club sports, due to the perception that it will accelerate the development of the athlete's skill level (Hash, 2000; Hill, 1987). Finally, coaches, parents, and athletes alike often believe that sport specialization is essential to remaining competitive with other athletes who decide to specialize early (Matheson, 1990).

The question of whether specializing in a single sport promotes quicker and better physical development or skill acquisition compared to multisport or multiactivity participation has been discussed and debated in numerous venues (e.g., National Association for Sport and Physical Education, 2010). Unfortunately, sport specialization is a difficult area for researchers to study due to individual differences in maturation rates, sport requirements, training techniques, and possible ethical

Early gymnastics training apparently does not affect growth and maturation. The typical small physique of elite gymnasts seems to result from self-selection.

concerns in conducting this type of research. We know very little about the potential benefits or negative consequences of early sport specialization, since there is a striking paucity of published literature on this topic. Nonetheless, continued discussions of youth sport specialization are important. This article addresses the question of whether early sport specialization provides a *physiological* advantage for future athletic success.

Is There a Physiological Advantage?

When considering the topic of youth sport specialization, the underlying premise is that highly specific training at an early age will improve the functioning of the body's main organ systems, beyond what normal growth and development or more diversified physical activities can achieve. Of the 11 organ systems cited by anatomy books, the systems that are most discussed in regard to their impact on sport performance are the *endocrine*, *muscular*, *nervous*, and *cardiovascular* systems. Research evidence clearly indicates that diversified fitness training (i.e., nonspecialized, multiactivity exercise) can have positive effects on the functioning of these organ systems when comparing untrained and trained preadolescents (American Academy of Pediatrics [AAP], 2000). However, research evidence is virtually nonexistent when it comes to comparing the effects of highly specialized, sport-specific training with those of diversified fitness training. The following sections will briefly discuss existing research concerning the effects of sport participation on the body's organ systems.

Endocrine System. Although limited, research does exist as to the impact of exercise training and sport on normal growth and maturation. Evidence to date does not suggest that sport participation accelerates or slows the rate of growth and maturation in boys or girls (Malina, 1994). Gymnasts have been studied to see whether their growth or development was abbreviated by early sport specialization. The concern was that intense, very specific training at a young age might have negative effects on normal endocrine functioning and thus affect athletes' growth (i.e., stature) and maturation. Though not conclusive, it appears that early gymnastics training does not negatively affect growth and development, but that the characteristic stature associated with elite gymnasts is a result of a self-selection into a sport that favors a particular body type (Stager, Wigglesworth, & Hatler, 1990). While it appears that specialized training does not negatively affect endocrine function, no studies have shown enhanced endocrine function in gymnastics or any other sport as a result of early sport specialization.

Muscular System. Over the past two decades, one form of exercise that has been investigated extensively is resistance training (i.e., lifting weights). Resistance-training studies involving prepubescent children have consistently shown improvements in muscular strength, power, and endurance, but with little to no muscular enlargement (i.e., muscle hypertrophy; Faigenbaum et al., 2009). These reported physical improvements are beyond the increases associated with natural growth and development and are noted to be the result of an improved ability to activate the existing muscle, not of increases in muscle size (Ozmun, Mikesky, & Surburg, 1994; Ramsay et al., 1990). The lack of muscle enlargement is generally attributed to the low levels of circulating anabolic hormones, particularly testosterone. No studies to date have shown that resistance training, let alone highly specialized training, enhances or alters endocrine function (i.e., hormone levels) above normal levels in prepubescent youths (Kraemer, Fry, Frykman, Conroy, & Hoffman, 1989).

Nervous System. During childhood, the nervous system also continues to develop. Quick reactions and skilled movements are possible only after the process of myelination is complete. Myelination involves the formation of fatty insulating

sheaths around portions of nerve cells that enable the nerves to conduct electrical signals throughout the body more rapidly. While motor skills do improve with exercise training, the improvements appear to be within each child's current level of developmental potential. There are no studies, to the authors' knowledge, that indicate a training-induced acceleration of the developmental process of myelination within the central or peripheral nervous systems.

Cardiovascular System. Aerobic training has been shown to elicit improvements in cardiovascular functioning in children (Rowland, 2005). Lower submaximal heart rates at standardized workloads, increases in maximal oxygen consumption, and decreases in body fat, when compared to untrained controls, have been reported. However, aerobic training and its associated benefits appear to be limited by the smaller heart size and lower blood volume in children, which means that early specialization does not produce super-endurance athletes. Clearly, children have the physiological capability to adapt to exercise training and improve their physical functioning. However, these improvements appear to be developmentally restricted (i.e., by a small heart), so there is no research evidence to suggest that early, high-intensity, specialized training offers improvements beyond those of regular physical exercise.

In summary, there is no direct research evidence supporting the physiological benefits of early sport specialization over those of a more diversified sport and physical activity approach. What is clear, and of growing concern to many involved in sport, is the increased frequency of injury in those practicing early sport specialization. The high-intensity training associated with specific, repetitive movement patterns greatly increases the risk for overtraining and its associated physiological maladies.

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While children can benefit from aerobic training, their level of development limits their improvement, which means that early specialization will not produce super-endurance athletes.

Increased Risk for Injury?

Participation in organized youth sports provides measureable improvements in physical fitness, but also involves the risk for injury. Determining the extent to which sport specialization specifically may predispose youths to injury, however, is particularly difficult. There are no research-based data or guidelines that define how much exercise training might be considered harmful, and no standardized methods exist for identifying or assessing overtraining in young athletes. Instead, studies reporting on sport injuries have primarily focused on injuries from one specific sport or addressed a particular injury type (e.g., knee, elbow, shoulder).

The most common method for expressing the magnitude of risk for a given sport or activity is to report injury incidence rates, typically defined as the number of new injuries that occur during a given period of sport participation time (e.g., number of injuries per X hours) or relative to the number of athletic exposures, defined as participation in a practice or game where there is a possibility of sustaining injury (Caine, Caine, & Maffulli, 2006). Unfortunately, differences in total training volume (i.e., frequency, intensity, and duration) and exposure to different training methods (i.e., coaching and equipment) associated with sport specialization, as well as individual differences in physical maturation, complicate interpretations of the available studies that report on sport-related injuries in young athletes. These inherent limitations frequently result in wide variations in reported injury rates (Caine, Maffulli, & Caine, 2008). Furthermore, several methodological differences in research exist, including injury-reporting methods and injury definition (Brooks & Fuller, 2006). Despite the wide variability in reported injury rates, a consistent finding is frequently noted: with increased participation in sports, including more frequent training and competition, comes a greater risk for injury (Brenner, 2007; Caine et al., 2008; Frisch, Croisier, Urhausen, Seil, & Theisen, 2009; Pluim, Staal, Windler, & Jayanthi, 2006; Van Langendonck et al., 2003; Washington et al., 2001).

The majority of injuries seen in young athletes are related to specific, repetitive movement patterns that result in damage to a tissue structure (e.g., bone, muscle, tendon). Overuse injuries (e.g., tendinitis, apophysitis, stress fractures), as they are typically called, generally occur when the athlete does not allow sufficient time for the tissue to heal and adapt to the imposed physiologic stress. These types of injuries constitute up to 50 percent of all injuries seen in pediatric medicine

(Dalton, 1992) and the prevalence of specific overuse sports injuries is continuing to rise with the increase in youth sport participation (Brenner, 2007; Fleisig, Weber, Hassell, & Andrews, 2009; Lynch, Waitayawinyu, Hanel, & Trumble, 2008; Petty, Andrews, Fleisig, & Cain, 2004). While excessive sport training can lead to overuse injuries in both children and adults, the potential for injury is likely greater in young (physically maturing) athletes. Rapid growth spurts can lead to motor coordination issues and joint inflexibility due to imbalances in the growth rates of bone relative to muscle and other connective tissues. In many instances, young athletes may not have learned the proper mechanics and technique for some of the repetitively performed movements in their particular sport. Also, they may not recognize the ambiguous signs and symptoms associated with fatigue and poor performance, thereby increasing their risk of overtraining or injury.

These concerns have prompted many organizations to recommend limits in the total volume of sport training and competition that young athletes engage in due to the potential long-term consequences on the musculoskeletal system and for future participation. The AAP's Council on Sports Medicine and Fitness recommends limiting a single sport activity to no more than five days per week (AAP, 2000). Moreover, young athletes should have a minimum of two to three months off each year from their particular sport to let injuries heal and prevent burnout (Brenner, 2007). In addition to avoiding some of the concerns related to overuse, overtraining, and burnout, this "time off" also allows young athletes to participate in other sports or activities (i.e., sport diversification).

Participation in multiple sports has several advantages, including increased exposure to different training philosophies, coaches, and athletes. Young athletes who participate in a variety of sports have fewer injuries and engage in sport longer than those who specialize early (AAP, 2000). Moreover, sport diversification will likely improve skills that are important for success in multiple sports, result in a well-rounded athlete, and increase the likelihood of achieving lifelong physical fitness and enjoyment of physical activity. Educating parents, coaches, and athletes about the unsubstantiated benefits and documented consequences of sport specialization is an important first step in helping them to gain a healthy perspective regarding sport participation. Decisions regarding the sport participation of young athletes should focus primarily on the child's motivation and personal goals, and on promoting enjoyment, skill development, success, and hopefully a physically active lifestyle.

Summary

Early specialization in sport has not been shown to enhance physiological systems more than diversified participation in physical activity and sport. On the other hand, research has documented the known negative physical effects associated with overtraining (i.e., injuries). The documented dangers clearly outweigh the potential yet unsubstantiated benefits and thus tip the balance against early sport specialization from a physiological standpoint.

Finally, genetics cannot be ruled out of the formula when considering what it takes to become an elite athlete in a sport. While the physical requirements for each sport vary greatly, the physical potential of an individual is dictated by his or her genetic makeup. In other words, no amount of intensive practice or sport specialization can compensate for genetic endowments that do not match the demands of the sport. An elite athlete is a rare combination of genetic, physical, and mental characteristics. This is clearly borne out by the very small percentage of individuals who actually make it to the highest levels of competition (e.g., only 0.08% of high school senior football players are drafted to the NFL; National Collegiate Athletic Association, 2007).

While on rare occasions a child prodigy is cultivated through years of specific practice, the scarcity of such occurrences suggests that it is literally a lucky gamble. Sport specialization, with its low-percentage payoff, seems a very costly venture, both monetarily and in regard to substantial injury rates. Numerous professional and sport organizations are starting initiatives to return to "early diversification" rather than "early specialization." The small chances of making it big with an "at all costs" approach should not supersede the real personal and social value of sport participation. Based on current evidence, coaches and parents would be well advised to exchange "youth sport specialization" for "youth sport diversification," and the hopes of "big bucks and notoriety" for the "enjoyment and lifelong physical benefits" that an active lifestyle can offer.

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