

[Primary Care]

Sports Specialization in Young Athletes: Evidence-Based Recommendations

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Context: Sports specialization is intense training in 1 sport while excluding others. Sports specialization in early to middle childhood has become increasingly common. While most experts agree that some degree of sports specialization is necessary to achieve elite levels, there is some debate as to whether such intense practice time must begin during early childhood and to the exclusion of other sports to maximize potential for success. There is a concern that sports specialization before adolescence may be deleterious to a young athlete.

Evidence Acquisition: PubMed and OVID were searched for English-language articles from 1990 to 2011 discussing sports specialization, expert athletes, or elite versus novice athletes, including original research articles, consensus opinions, and position statements.

Results: For most sports, there is no evidence that intense training and specialization before puberty are necessary to achieve elite status. Risks of early sports specialization include higher rates of injury, increased psychological stress, and quitting sports at a young age. Sports specialization occurs along a continuum. Survey tools are being developed to identify where athletes fall along the spectrum of specialization.

Conclusion: Some degree of sports specialization is necessary to develop elite-level skill development. However, for most sports, such intense training in a single sport to the exclusion of others should be delayed until late adolescence to optimize success while minimizing injury, psychological stress, and burnout.

Keywords: intense training; children; adolescents; overtraining; exercise

Youth sports participation has evolved from child-driven, recreational free play for enjoyment to adult-driven, highly structured, deliberate practice devoted to sports-specific skill development.^{12,32} Emphasis is placed on developing and attaining sufficient skill levels to excel at many levels of athletics.^{35,44} This evolution in youth sports may have developed as a result of society's increasing regard for successful athletes, who enjoy significant recognition and financial rewards for their achievements. Consequently, many children and adolescents participating in sports now aspire to achieve elite levels.^{44,46}

The amount of training necessary to develop elite-level sports skills has long been debated. Ericsson et al defined the necessary components for expert skill acquisition in musicians, and these concepts have been extrapolated to sports.¹⁶ To achieve expertise, musicians must practice 10 000 hours over 10 years. This intense practice is more likely to be successful if begun during the early

years of development. Lesser practice and a delayed start resulted in less expertise. In contrast, others believe that fewer hours are needed to achieve elite-level skills and that intense specialized training is more effective during later stages of development.⁴²

A survey of elite young athletes (Training of Young Athletes Study) found that parents were the strongest influence on the initiation of a sport (gymnastics, tennis, swimming, soccer) while coaches were the strongest influence on their decision to perform intense training.⁸ Similarly, a survey of 153 high school athletic directors suggested that coaches were the most powerful influence to specialize in a single sport.²³ This may create a disconnect: initially, a parent introduces the child to the sport; successes follow; then the coach encourages specialized training to achieve higher level success. The parent may acknowledge and encourage increased participation, not want to interfere with the child-coach relationship, and/or

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assume that this path is necessary for continued success. If the child has an injury as a result of training, the medical provider may treat the injury but may not have enough information to provide appropriate training recommendations for injury prevention.

DEFINING SPORTS SPECIALIZATION

Sports specialization is defined as intense, year-round training in a single sport with the exclusion of other sports.^{29,35} Variations on this general theme exist, with disagreement on what volume of training constitutes “intense” and whether year-round participation or exclusion of all other sports is essential for classifying an athlete as specialized. Some advocate that a minimum volume of training is required to meet the definition,^{16,42} while others define specialization as simply limiting participation to a single sport on a year-round basis, regardless of training volume.²³ Ericsson et al proposed 3 stages in becoming a specialist or expert musician: (1) start at an early age, (2) specialize and increase participation, and (3) dedicate full-time commitment.¹⁶ Côté et al further characterizes the intense training as the ultimate purpose of improving performance (“deliberate practice”) as opposed to enjoyment of the activity (“deliberate play”).¹⁴ Soberlak and Côté developed a different approach when evaluating elite hockey players: sampling (ages 6-12 years), specializing (ages 13-15 years), and investment (ages 16+ years).⁴² The distinction of sports specialization should really be focused on children who commit exclusively to a sport during the early-to-middle elementary school years, since later specialization is very common and almost standard in today’s society.⁴⁶

These definitions exclude athletes who perform a large volume of intense training in a single sport throughout the year but still compete in others concomitantly and those who train intensely in a single sport during parts of the year with variable year-round participation. As a result, sports specialization may be better defined along a continuum.

In an ongoing study, the rates of sports specialization in young athletes (8-18 years old) presenting to a pediatrician or family physician for sports physicals were compared with those presenting for an injury.²⁹ Based on questions about their sports participation, a sports specialization score was tabulated for each athlete. Preliminary data suggest that the most relevant question is whether they have quit other sports to focus on 1 sport. This factor accounted for 38% of the variance in the sport specialization score.²⁹ The second-most relevant question (32% of the variance) was whether the child had spent more than 3 quarters of their training time in 1 sport. Year-round and/or out-of-state training and competition were also relevant in determining level of specialization.

TRENDS IN SPORTS SPECIALIZATION

In the United States, participation in organized sport has increased from approximately 9% of children 6 years and younger in 1997 to 12% in 2008.³⁵ A majority (77.7%) of high school athletic directors reported an increasing trend in sports

specialization.²³ Further evidence for early sports specialization is the growing number of travel leagues at 7 or 8 years of age³⁷ and an increase in young Olympic athletes.⁴⁶

Rates of sports specialization appear to increase with age. A study of 519 US Tennis Association junior tennis players found that 70% began specializing at an average age of 10.4 years old.²⁸ Specialization rate gradually increased after 14 years, with 95% of players by age 18 years. However, enjoyment and satisfaction ratings decreased in players older than 14 years old ($P < 0.01$).

The reality is that few athletes achieve the elite or professional level.³⁵ Less than 1% of young athletes 6 to 17 years of age achieve elite status in basketball, soccer, baseball, softball, or football.³⁵ The data are similar for Germany²¹ and Australia.³⁹

DOES EARLY SPECIALIZATION PROMOTE SUCCESS IN SPORTS?

There is general agreement that the number of hours spent in deliberate practice and training positively correlates with level of achievement in both individual and team sports; whether this intense practice must begin during early childhood and to the exclusion of other sports is a matter of debate. There are relatively few data to validate these theories. Professional medical organizations have published position statements on sports specialization and intense training in young people but have limited data upon which to base their recommendations and thus rely on expert opinion.^{2,3,17,26,36}

Early vs Late Intense Training

The best musicians spent over 10 000 hours practicing alone, while their less successful peers had accumulated 7000 hours or less, coinciding with critical periods of biological and cognitive development. Musicians began training around 5 years of age; those who began after age 5 years were unable to catch up.

Research in athletes has not consistently demonstrated that early intense training is essential for attaining an elite level in all sports (Table 1).^{5,6,13,21,22,24,25,30,31,38,42,45} Data from these studies are limited by a subset of sports, small samples sizes, and retrospective design; few included athletes who began intense training before 12 years. Two studies demonstrated that accomplished elite athletes were more likely to initiate intense training in early and middle childhood; both were women’s rhythmic gymnastics. In gymnastics, peak performance occurs before full maturation, requiring intense training before puberty.^{25,30}

In contrast, elite athletes in other sports were more likely to initiate intense training later in adolescence. World-class athletes were more likely to start competing at a later age, competed in other sports, and were typically selected for a sport federation program at an older age than those at the national level.⁴⁴ A recent survey of 148 elite and 95 near-elite Danish athletes (mean age, 24.5 years; track and field, weightlifting, cycling, rowing, swimming, skiing) found that the elite group began intense training at a later age and spent fewer hours practicing its main sport up to the age of 15 years

Table 1. Evidence for and against early sports specialization to achieve elite status

Study	Sport	Athletes	Before Age 12 Years ^a		After Age 12 Years ^a		Study Conclusions
			Begin ^b	Specialize ^c	Begin ^b	Diversify / Specialize ^d	
Hume et al ²⁵	Rhythmic gymnastics	106 across all levels	+			+	Amount of gymnastic training during development is related to level of attainment. All gymnasts participated in other sports, with no difference between elites and subelites. Enjoyment of gymnastics was strong predictor of attainment.
Law et al ³⁰	Rhythmic gymnastics	6 elite, 6 subelite	+	+			Elites and subelites began intense training at similar ages, but elites were involved in fewer other activities from age 4-16 years and accumulated more hours of training by age 16 years.
Heisen et al ²²	Men's soccer, men's field hockey	33 intl, 39 natl, 52 provincial				+	Soccer began practicing at age 5 years, field hockey at age 9 years. Hours spent in practice were similar among levels until age 12 years. After age 12 years, international players spent more time in practice than national players, and national players spent more than provincial players.
Hodges and Starkes ²⁴	Wrestling	21 elite, 21 club level				+	Elite wrestlers spent more time training after age 16 years compared with club-level wrestlers. However, since all subjects began intense training at 13.2 ± 0.6 years, comparison to early intense training (before age 12 years) was not possible.
Soberiak and Côté ⁴²	Men's ice hockey	4 elite				+	Elite players intensified their deliberate hockey training in late adolescence and played other sports during developmental years.
Carlson ¹³	Men's, women's tennis	10 elite, 10 near-elite				+	Elite players began intense training and specialized later (after age 13-15 years) than near-elites (age 11 years).
Lidor and Lavyan ³¹	Various men's, women's sports	63 elite, 78 near-elite				+	Elite more likely than near-elite athletes to begin intense training after age 12 years and to have played > 1 sport during developmental years.
Gullich and Emrich ²¹	Olympic sports	1558 German athletes (Olympic promotion programs)				+	Elite athletes began intense training and competition in their sport later than near-elites (11.4 vs 10.2 years and 13.1 vs 12.0 years). More elites participated in > 1 sport from age 11 years than near-elites (64% vs 50%).

(continued)

Table 1. (continued)

Study	Sport	Athletes	Before Age 12 Years ^a		After Age 12 Years ^a		Study Conclusions
			Begin ^b	Specialize ^c	Begin ^b	Diversify / Specialize ^d	
Moesch et al ³⁸	Sports measured in cm, g, or s ^e	148 elite, 95 near-elite			+		Elite athletes began intense training at a later age compared with near-elites. Near-elites accumulated more hours of training by ages 9, 12, and 15 years than elites, while elites accumulated more training by age 21 years than near-elites.
Baker et al ⁵	Men's, women's field hockey; men's basketball; women's netball	15 elite, 13 near-elite			+	+	Elites accumulated more hours of sport-specific practice from age 12 years onward. However, all subjects began intense training at about age 12 years, so unable to compare to an early intense training group. Elites had broader range of sports experiences throughout their careers compared with near-elites.
Barynina and Vaitsekhovskii ⁶	Men's, women's swimming	Elite Russian swimmers (number not reported)				+	Swimmers who began specializing before 11 years of age spent less time on a national team and retired earlier than later specialists.
Wall and Côté ⁴⁵	Boys' ice hockey	Parents of 8 minor league players (mean age, 13.9 y) and 4 ex-minor league players (mean age, 14.5 y)			+		Dropouts began off-ice training earlier than non-dropouts (11.75 vs 13.8 years) and spent more hours in off-ice training (107 vs 6.8 per year). Both groups participated in a similar number of other sports (4.75) from 6 to 13 years of age.

^aPlus sign (+) indicates "evidence for."^bBegin intense training.^cSpecialize in sport.^dDiversify early, specialize in sport.^eCanoeing/kayak, cycling, orienteering, rowing, sailing, skiing, swimming, track and field, triathlon, weight lifting.

compared to the near-elite group.³⁸ By 18 years of age, the 2 groups had accumulated a similar number of practice hours, but by 21 years, elites had accumulated more practice hours.³⁸ Involvement in other sports was not different between the groups and did not predict success. These sports require a high physical and aerobic capacity and lower technical or tactical requirement relative to ball and performance sports (gymnastics⁴¹ and figure skating⁴⁵). While some physiologic adaptations to aerobic training occur in childhood, they are much less pronounced than adaptations in adolescence.

Early vs Late Specialization

For most sports, early diversification is more likely to lead to success (Table 1).^{5,6,13,21,22,24,31,38,42,45} A survey of 376 female Division 1 intercollegiate athletes found that the majority had their first organized sports experiences in other sports.³⁵ Only 17% had previously participated exclusively in their current sport; the majority simultaneously participated in individual sports (swimming, track and field, diving, tennis, and golf).³⁵ Early diversification provides the young athlete with valuable physical, cognitive, and psychosocial environments and promotes motivation.^{1,2,36,38,46}

Among high-level athletes of basketball, netball, and field hockey, the greater the number of activities that the athletes experienced and practiced in their developing years (ages 0-12 years), the less sports-specific practice was necessary to acquire expertise in their sport.^{4,5} This is transfer of pattern recall skills from one sport to another, most pronounced during the early stages of involvement.¹ Early diversification followed by specialization may lead to more enjoyment, fewer injuries, and longer participation, contributing to the chances of success.^{6,20,45}

Other Factors Promoting Success in Sports

Early participation differences between elite youth soccer players who progressed to professional status at age 16 years and those who did not revealed that those who progressed had accumulated more hours per year in unstructured soccer activities between the ages of 6 and 12 years. There was no difference in soccer practice, soccer competition, or other sports in that time frame.¹⁹ This suggests that elites sought more unstructured soccer during free time. This is supported by data that show that enjoyment of the sport and intrinsic motivation predict attainment.^{20,25,31} Successful elite tennis players often have good long-term relationships with the same coach, access to tennis courts, and less overall demands for success compared with age-matched controls.¹³

RISKS OF SINGLE-SPORT INTENSE TRAINING

The risks of single-sport intense training include adverse psychological stress and premature withdrawal from competitive sport. Current data suggest that intense training and specialization may be independent risk factors.^{28,29}

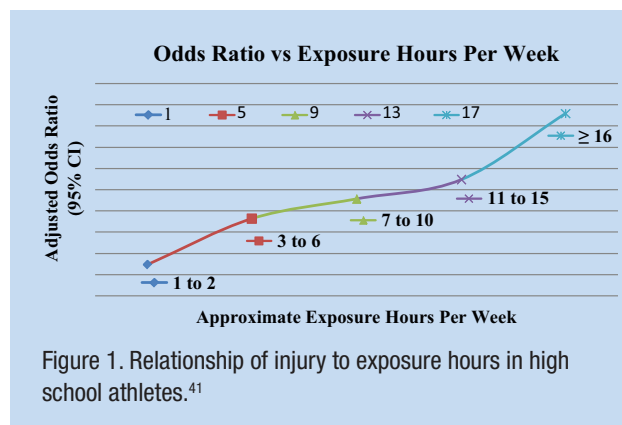


Figure 1. Relationship of injury to exposure hours in high school athletes.⁴¹

Injury

The risks of intense training in elite young athletes in the United Kingdom was relatively low (rates of injury < 1/1000 hours of training) with few serious consequences.^{7,34} Training volumes were often < 16 hours per week; lower than for other intensely trained athletes.^{29,41} A 10-year follow-up suggests that injury incidence is significantly higher for athletes competing at an international level (87.5%) and a regional/country level (64.0%) compared with those competing at a national level (16.7%) or recreational level (47.1%).³³

Higher training volumes may increase risk for injury in a variety of sports.⁴¹ In 2721 high school athletes, increased exposure was the most important risk factor for injury.⁴¹ There was a linear relationship between exposure and risk of injury (odds ratio, 8.28), showing significantly elevated risk once training volume exceeded 16 hours per week (Figure 1). Cumulative match (or competition) exposure also carries a significant risk: medical withdrawals increased in national tennis players after playing > 5 matches per year in supernational tournaments.²⁷ Players who specialized only in tennis were 1.5 times more likely to report an injury.²⁸ A 10-year prospective analysis of 481 youth baseball pitchers (9-14 years old) found that those who pitched more than 100 innings per year were 3.5 times more likely to be injured.¹⁸ Others have found a significantly increased risk (odds ratio, 5.05) for shoulder or elbow surgery if pitching more than 8 months per year.⁴⁰

The risk of injury from intense training and specialization may be affected by age, competitive level, growth rate, and pubertal maturation stage. Higher rates of injury were found in athletes older than 13 years of age and those at higher competitive levels.¹⁵ Peripubertal gymnasts are more likely injured during periods of rapid growth (Tanner stages 2 and 3).¹¹ Fracture risk is also higher during peak height velocity.^{9,29}

Psychological Stress and Dropping Out of Sports

Early sports specialization may contribute to burnout and dropping out of sports (Table 1).^{5,6,13,22,24,25,30,38,42,45} Swimmers who specialized early spent less time on the national team

and retired earlier than athletes who specialized later.⁶ Minor league ice hockey players (boys) that dropped out of the sport started off-ice training earlier and spent more time in off-ice training than those who continued to compete.⁴⁵

In a retrospective 10-year review, 1 out of 5 of the most competitive elite athletes reported injury as the reason for quitting one's sport.¹⁰ Rhythmic gymnasts, those who specialized earlier and spent more hours training from age 4 to 16 years, rated their health lower and experienced less fun.³⁰ Junior tennis players who burned out early had less input in their training, higher perceived parental criticism and expectations, and lower levels of extrinsic motivation.²⁰

Elite Russian swimmers who dropped out reported that the main reasons for leaving the sport were psychological fatigue, general health, and difficult loads.⁶

CONCLUSION

Some degree of sports specialization is necessary to attain elite-level skill.^{2,3,17,26,36} However, for most sports, intense training in a single sport to the exclusion of others should be delayed until late adolescence to optimize success while minimizing risk for injury and psychological stress.^{5,6,13,22,24,25,30,38,42,45}



Clinical Recommendations

SORT: Strength of Recommendation Taxonomy
A: consistent, good-quality patient-oriented evidence
B: inconsistent or limited-quality patient-oriented evidence
C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
1. Intense single-sport specialized training is necessary for elite skill development. For most sports, this training should begin in late adolescence to optimize sports success. ^{5,6,13,22,24,25,30,38,42}	B
2. Intense single-sport specialized training in most sports should be delayed until late adolescence to reduce the risk for injury and adverse psychological stress. ^{6,9,11,15,24,25,28,30,38,45}	B

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