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Narrative Review

Health Consequences of Youth Sport Specialization

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Sport specialization is a training method now commonly used by young athletes who hope to achieve elite-level success. This may be defined as (1) choosing a main sport, (2) quitting all other sports to focus on 1 sport, and (3) year-round training (greater than 8 months per year). A number of sports medicine organizations have published recommendations based on the limited evidence available on this topic. The objective of this article was to perform a narrative review of the currently available evidence and sports medicine organizational recommendations regarding sport specialization and its effects on health to guide athletic trainers and sports medicine providers. To accomplish this goal, we conducted a narrative review of articles and position statements on sport specialization published from 1990 through 2018. Injury, overuse injury, serious overuse injury, and lower extremity injury were likely associated with higher degrees of sport specialization in various populations. Sports medicine organizations in general recommended against sport specialization in young athletes and instead promoted multisport participation for physical and psychological benefits. Few long-term data suggest that sport specialization has negative health-related quality-of-life consequences. Higher degrees of sport specialization likely pose risks of overuse injury; however, the age of specialization at which this risk occurs is not known. Because different populations and sports activities may put children at risk for certain injuries, future researchers should monitor large populations with sport-specific prospective active surveillance.

Key Words: athletic injuries, stress, pain, athletes, children, adolescents

In the United States, nearly 60 million youths participate in organized athletics, and nearly 8 million adolescents participate in high school interscholastic sports each year.[1,2] However, recent estimates[3,4] indicated that approximately half of adolescent athletes participated on club teams in addition to their school-based teams in order to train year-round in a chosen sport. This increasing emphasis on specialization in youth sports (ie, athletes 18 years old or younger) is a growing concern among athletic trainers (ATs), physicians, and other health care providers. A number of position statements[1,5–9] from medical organizations have provided recommendations for youth athletes to reduce the risks of specialization.

Recent authors[3,10–13] have reported prevalence rates of sport specialization among youth athletes of 17% to 41%. Rates vary depending on factors such as athlete sex, age, sport, socioeconomic status (SES), school size, and geographic location.[3,10–13] The prevalence rates indicate that specialization is a relatively common occurrence in modern youth sports. One proposed consequence of increasing rates of specialization is the potential for psychological burnout among youth athletes who specialize and train year-round starting at an early age.[14–17] The degree of specialization, as measured by the Jayanthi scale, is also thought to contribute to these adverse health effects.[18] Of even greater concern may be the effect of SES on sport specialization, which creates the potential for reduced access to sports among those youths who cannot afford (the time or money) to focus on a single sport year-round.[12,19]

However, of more immediate concern to ATs and other clinicians working in the youth sports arena may be the potential physical risks of specialization and overtraining, such as overuse injury, acute injury, and illness. Therefore, the aim of our narrative review was to provide an overview of the current state of evidence related to the association of sport specialization with injury and illness in youth athletes. We also highlighted the recommendations made in an attempt to reduce the physical risks of specialization and the evidence supporting those recommendations (or lack thereof).

METHODS

Data Sources

A search of PubMed using the terms (*youth*) AND (*sport specialization*) AND (*injury OR illness*) for peer-reviewed articles was performed in July 2018. Additionally, the authors contributed relevant articles and used select reference lists to identify relevant papers that were not found in the initial search. Position and consensus statements that provided recommendations regarding sport specialization were gathered from medical and athletic organizations. Because we chose to conduct a narrative

review rather than a systematic review, we did not strictly follow the guidelines for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA; http://www.prisma-statement.org/).

Study Selection

The criteria for article inclusion were (1) original research or consensus or position statement, (2) written in English, (3) published in 1990 or later, and (4) an aspect of sport specialization (such as number of sports played, months or hours per week participating in a single sport, playing on multiple teams of the same sport at the same time) was examined as a risk factor for injury or illness in youth athletes. Articles were excluded if they were (1) narrative or systematic reviews or meta-analyses, (2) editorials, (3) critically appraised topics, (4) abstracts, or (5) based on animal research.

Data Extraction

After the initial search, we extracted and read the relevant articles. Final decisions for article inclusion were made by consensus of the study team, which consisted of 2 sports medicine physicians (N.A.J., T.C.L.), 1 AT with a doctoral degree (E.G.P.), and 1 orthopaedic surgeon with sports medicine training (P.D.F.), all of whom were established researchers in the area of sport specialization. Any articles that initially lacked consensus for inclusion were discussed by the team before a decision was reached. Relevant consensus and position statements that provided recommendations regarding sport specialization are listed in Table 1. Relevant original research articles examining aspects of sport specialization as a risk factor for injury or illness are presented in Table 2.

FINDINGS AND DISCUSSION

What Do Organizations Recommend Regarding Sport Specialization?

Organizations including the American Academy of Pediatrics (AAP), American Medical Society for Sports Medicine (AMSSM), American Orthopaedic Society for Sports Medicine (AOSSM), Fédération Internationale de Médecine du Sport (FIMS), International Olympic Committee (IOC), National Athletic Trainers' Association (NATA), and National Strength and Conditioning Association (NSCA) have released position statements regarding early sport specialization and youth athlete development. The recommendations can be subdivided into several categories—the official position on the topic, risks associated with early specialization, benefits of sports sampling, appropriate age of specialization, and miscellaneous suggestions—to be considered when analyzing a young athlete's decision to train or specialize in a single sport (Table 1).

Definition of Sport Specialization

No consistent definition of sport specialization exists. One of the original definitions suggested that sport specialization is "intense, year-round training in a single sport at the exclusion of other sports."[1,6,28] The 3 key components of this definition (year-round training, choosing a main sport, and quitting other sports) became the basis for the most commonly used method of classifying specialization, the 3-point Jayanthi scale.[3,4,10–13,18,19,29,30,31] This scale classifies an athlete as having a low, moderate, or high level of specialization based on his or her responses to 3 *yes*/*no* questions. To determine if a young athlete is specialized, one should ask (1) whether the athlete has quit all other sports to focus on the main sport (or only ever played 1 sport), (2) if the primary sport was viewed as more important than other sports, and (3) if more than 8 months in the year was spent training or participating in the primary sport. A *yes* answer to a question receives 1 point: a total score of 0 to 1 points is classified as *low specialization*, 2 points as *moderate specialization*, and 3 points as *high specialization*.

Sports Sampling

All 7 of the organizations listed in Table 1 support early sports sampling due to the numerous health benefits provided.[1,5–9] Early exposure to a variety of sports is thought to promote longer-term success in and enjoyment of sports.[5,7] It also allows athletes who do eventually specialize at an older age to identify which sport best fits their interests, physique, and capabilities.[7] Moreover, movement diversity allows young athletes to acquire a broader range of neuromuscular patterns that may be protective against overuse injury.[6–8] The AAP, AMSSM, and AOSSM recommended participation in multiple sports at least until physical maturation.[1,5,6]

Early Sport Specialization

The AAP and AMSSM did not specify an age threshold for "early" specialization; however, the consensus was that specialization before adolescence may increase the risks of overuse injuries and burnout.[1,5,6] The AOSSM position statement first introduced the concept of *early sport specialization*, which involved choosing a single sport earlier than age 12.[5] Currently, no strong evidence supports this age recommendation, but further studies may help to identify an age (or stage of development) when these risks of chronic injury and burnout increase. Although these organizations consistently discouraged early specialization and promoted exposure to a wide array of sports, sports that require skill development and peak performance before puberty ends may be the few exceptions. Examples provided by the AAP, AMSSM, AOSSM, and Council on Sports Medicine and Fitness were dancing, diving, figure skating, and gymnastics.[1,5,6] Early specialization may be inevitable at the elite level in particular sports, as these athletes tend to perform optimally in their teens and early 20s.[6] Not all organizations view sport-specialized training as universally detrimental. The IOC suggested in 2015 that with proper precautions and a solid support system, it is indeed possible for athletes who specialize at an early age to have a positive experience.[20]

Intensive Training and Age of Specialization

A major concern is that early specialization has been associated with increased training and competition loads.[1,8] From a biomechanical standpoint, these may result in excessive exposure to a narrow spectrum of repetitive body

Table 1. Position Statements on Early Sport Specialization from Various Societies

Topic	American Academy of Pediatrics[6]	American Medical Society for Sports Medicine[1]	American Orthopaedic Society for Sports Medicine[5]	Fédération Internationale de Médecine du Sport[9]	International Olympic Committee[20]	National Athletic Trainers' Association[7]	National Strength and Conditioning Association[8]
Position on early sport specialization	Discouraged	Discouraged	Discouraged	Discouraged	Can be acceptable and healthy if there is broad range of biomechanical exposures within sport, as well as sport-life balance[0]	Discouraged	Discouraged
Psychosocial and physical risks of early specialization	Increases chances of injuries, stress, burnout	May increase rates of overuse injury and burnout	Risk for burnout, overuse injury, decrements in training	Intensified training leads to physical and mental stress and increased rates of dropout	Can lead to increased load, decreased recovery, overuse injury, and burnout	Increases overuse injury, risk for nutritional and sleep deficits, psychosocial concerns, and burnout	Increased overuse injury, dropout, blunted motor skill portfolio
Benefits of early, diversified training	Increases likelihood of lifetime sports involvement, physical fitness, and possibly elite participation	May be more effective in developing elite-level skill due to skill transfer	Increased long-term participation in sports, increased personal development	Helps identify sports that best fit interests, increases success/ enjoyment of sport, and decreases attrition	Fosters development of wider scope of athletic and social skills; encourages sustained sports participation and enjoyment	Enhances general fitness and aids in motor development	Increases overall athleticism and reduces injury risk; facilitates longer sporting careers, increased chance of sustained participation
Appropriate age of specialization	Late adolescence	Late adolescence	Late adolescence (age 16)	Not defined	Not defined	Not defined	Not defined
Exception sports	Diving, figure skating, gymnastics	Diving, figure skating, gymnastics, swimming	Figure skating, gymnastics	Not specified	Not specified	Not specified	Not specified
Other recommendations	Take off 1–2 d/wk and 3 mo/y in 1-mo increments	Further research needed regarding effect of specialization on overuse injuries, controlling for intensity and work load	Periodic strength and conditioning to enhance diverse motor-skill development	Competitive weightlifting/ power lifting should not be recommended before completion of puberty; excessively long distance running not recommended before maturation	Athlete development should be viewed on individual basis; definition of athletic success should be centered on the athlete as a whole, unique person	Take time off between sport seasons and 2–3 mo away from sport	Neuromuscular training should be started in early childhood to promote long-term physical development

Table 2. Studies Examining Youth Sport Specialization and Injury Risk Continued on Next Page

Study	Design	Demographics	Sport(s)	Risk Factor	Outcome	HR, OR, Percentages, or RR (95% Confidence Interval)	*P* Value
O'Kane et al[21] (2017)	Case control	Female, age 12–15 y	Soccer	Playing on more than 1 soccer team in the prior week	Knee overuse injury	OR = 2.5 (1.08, 5.35)	
				Players who participated in other physical activities[a]	Lower extremity overuse injuries[b]	OR = 0.50 (0.27, 0.86)	
					Knee overuse injury	OR = 0.39 (0.15, 0.81)	
Post et al[3] (2017)	Cross-sectional	High school (grades 9–12)	Multiple	Athletes with high competition volume[c]	Reporting a previous lower extremity injury[d]	OR = 2.08 (1.55, 2.80)	<.001
				Athletes who participated in a club sport	Reporting a previous lower extremity injury[d]	OR = 1.50 (1.20, 1.88	<.001
				Athletes who were highly specialized[e]	Reporting a previous lower extremity injury[d]	OR = 2.58 (1.88, 3.54)	<.001
Pasulka et al[22] (2017)	Case control	Age 7–18 y	Various	Single-sport specialized athletes in individual sports compared with team sports	Overuse injury	OR = 1.67	.037
					Serious overuse injury[f]	OR = 2.38	.011
Padaki et al[23] (2017)	Descriptive epidemiologic	Age 7–18 y	Multiple	Playing a sport 11–12 mo/y	Reporting a sport-related injury history[g]	46% versus 26%	<.01
Post et al[13] (2017)	Case-control study	Age 12–18 y	Multiple	Athletes with a high versus low level of specialization[e]	Reporting a previous acute injury of any kind	OR = 1.58 (1.24, 2.00)	<.001
					Reporting an overuse injury in the previous year	OR = 1.45 (1.07, 1.99)	.011
					Reporting a previous upper extremity acute injury	OR = 1.43 (1.09, 1.88)	.011
					Reporting a previous lower extremity acute injury	OR = 1.41 (1.07, 1.85)	.015
				Playing >8 mo/y	Reporting a previous upper extremity overuse injury	OR = 1.68 (1.06, 2.80)	.04
				Playing >8 mo/y	Lower extremity overuse injury	OR = 1.66 (1.22, 2.30)	.001
Bell et al[10] (2016)	Cross-sectional	Age 13–18 y, volleyball, female only	Soccer, basketball, tennis, volleyball	Training >8 mo/y	Reporting a history of any knee injury	OR = 2.32 (1.22, 4.44)	.009
					Reporting a history of overuse knee injury	OR = 2.93 (1.16, 7.36)	.018
					Reporting a history of hip injury	OR = 2.74 (1.09, 6.86)	.026
Olsen et al[24] (2006)	Case control	Male, age 14–20 y	Baseball	Pitched in competitive baseball for >8 mo/y	Elbow or shoulder injury requiring surgery	OR = 5.05 (1.39, 18.32)	
Hall et al[25] (2015)	Retrospective cohort	Female, middle-high school, n = 546	Basketball, soccer, volleyball	Specialization[h] compared with multisport	Presence of patellofemoral pain	RR = 1.5 (1.0, 2.2)	.038
					Presence of OSD or SLJ/patellar tendinopathy	RR = 4 (1.5, 10.1)	.005

Table 2. Continued From Previous Page

Study	Design	Demographics	Sport(s)	Risk Factor	Outcome	HR, OR, Percentages, or RR (95% Confidence Interval)	*P* Value
Jayanthi et al[18] (2015)	Case control	Age 7–18 y, n = 1190	Multiple	Degree of sport specialization,[e] adjusted for age and hours training in sports	Any injury versus uninjured	OR = 1.27 (1.07, 1.52)	<.01
					Serious overuse injury[f,i] versus overuse injury	OR = 1.36 (1.08, 1.72)	<.01
				Highly specialized athletes[e]	Any injury	OR = 1.58 (1.11, 2.24)	<.05
					Acute injury	OR = 1.19 (0.75, 1.89	.472
					Any overuse injury (serious and nonserious)	OR = 1.5 (1.01, 2.22)	<.05
					Serious overuse injury	OR = 2.25 (1.27, 3.99)	<.001
				Moderately specialized athletes[e]	Any injury	OR = 1.44 (1.04, 1.98)	<.05
					Acute injury versus overuse injury	OR = 1.52 (1.01, 2.29)	<.05
					Serious overuse injury versus overuse injury	OR = 2.04 (1.18, 3.51)	<.01
				Participating in more hours of sports/wk than age in y	Any injury	OR = 1.59 (1.17, 2.19)	<.05
					Serious overuse injury[f] versus overuse injury	OR = 2.07 (1.40, 3.05)	<.001
				Ratio of organized sports to free play time >2 : 1 h/wk, adjusted for age and hours training in sports	Any injury	OR = 1.87 (1.26, 2.76)	<.01
					Acute injury versus overuse injury	OR = 0.58 (0.42, 0.80)	>.001
					Serious overuse injury[f] (not adjusted for age and hours training)	OR = 1.87 (1.26, 2.76)	<.01
Yang et al[26] (2014)	Cross-sectional	Male, age 9–18 y, n = 754	Baseball	Pitchers who pitched for multiple (>1) teams with overlapping seasons in the past 12 mo	Arm tiredness when pitching[j]	OR = 3.37 (1.76, 6.30)	<.05
					Arm pain when pitching[j]	OR = 1.85 (1.02, 3.38)	<.05
				Pitching competitive baseball for >8 mo/y	Arm pain when pitching[j]	OR = 1.68 (0.82, 3.44)	>.05
				Pitched on consecutive days in the past 12 mo	Arm tiredness when pitching[j]	OR = 4.36, (1.87, 10.15)	<.05
					Arm pain when pitching	OR = 2.53 (1.14, 5.60)	<.05
				Pitched in multiple (>1) games/d	Arm pain when pitching[j]	OR = 1.89 (1.03, 3.49)	<.05
				Arm tiredness when pitching: often[k]	Pitching-related injury[l]	OR = 7.88 (3.88, 15.99)	<.001
				Arm tiredness when pitching: sometimes[k]	Pitching-related injury[l]	OR = 3.71 (2.35, 5.87)	<.001
				Arm pain when pitching: often[k]	Pitching-related injury[l]	OR = 7.35 (3.47, 16.21)	<.001
				Arm pain when pitching: sometimes[k]	Pitching-related injury[l]	OR = 5.4 (3.75, 7.79)	<.0001

Table 2. Continued From Previous Page

Study	Design	Demographics	Sport(s)	Risk Factor	Outcome	HR, OR, Percentages, or RR (95% Confidence Interval)	*P* Value
McGuine et al[4] (2017)	Prospective cohort	Grades 9–12, n = 1544	Multiple	Athletes with a moderate versus low level of specialization[e]	Incidence of lower extremity injuries[m]	HR = 1.51 (1.04, 2.20)	.03
				Athletes with a high versus low level of specialization[e]	Incidence of lower extremity injuries[m]	HR = 1.85 (1.12, 3.06)	.02
Buckley et al[27] (2017)	Cross-sectional	High school, collegiate, and professional athletes, n = 3090	Multiple	Current high school and collegiate athletes compared with current professional athletes	Recall of any sport-related injury[n]	39.0% and 32.4% versus 25.4%, respectively[o]	<.001

Abbreviations: HR, hazard ratio; OR, odds ratio; OSD, Osgood-Schlatter disease; RR, risk ratio; SLJ, Sinding-Larsen-Johansson syndrome.

[a] Physical activities included aerobics, bicycling, golf, gymnastics, Pilates, running, skiing, swimming, waterskiing, weight lifting, and other activities.

[b] Injuries to the groin, hip, thigh, knee, lower leg, ankle, or foot were included in lower extremity injuries.

[c] Defined as >60 primary sport competitions within the past year.

[d] Defined as an injury that occurred during sport and that caused the athlete to seek medical care.

[e] Sport-specialization criteria: year-round training (>8 mo), choosing a main sport, and quitting all other sports to focus on 1 main sport (low = meets 0 or 1 criterion, moderate = 2, high = 3) from Jayanthi et al.[18]

[f] Defined as those for which the physician-recommended treatment included at least 1 mo of rest from sports.

[g] Unspecified injury, ranging from ankle sprains to operative conditions such as anterior cruciate ligament ruptures and ulnar collateral ligament ruptures.

[h] Defined as participation in only 1 sport.

[i] Serious overuse injuries included spondylolysis, pars stress injuries to the spine, osteochondritis dissecans, overuse elbow/ligament injuries, and all other ankle, foot, leg, knee stress fractures.

[j] Self-reported, in the past 12 mo. Response choices were *often*, *sometimes*, and *never*.

[k] Adjusted for age, body mass index, and region (geographic).

[l] Defined as a pitching-related injury (such as shoulder or elbow pain) that caused the athlete to miss pitching in at least 1 practice or game in the past 12 mo.

[m] Defined as any acute-, gradual-, or recurrent-onset injury to the lower extremity musculoskeletal system. In addition, each lower extremity injury must have (1) occurred as a result of participation in an interscholastic sport practice or competition and (2) required medical attention by an athletic trainer or physician. All lacerations, abrasions, and contusions to the lower extremity were excluded.

[n] Defined as the percentage of *yes* responses to "Did you ever sustain an injury that you attributed to specializing in 1 sport?"

[o] A higher percentage of current collegiate athletes specialized to play a single sport during their childhood/adolescence (high school = 45.2%, collegiate = 67.7%, professional = 46.0%; $P < .001$). This may suggest that early sport specialization can be a factor in the occurrence of early sport-related injury, but of course, multiple factors affect the occurrence of injury in sport.

movements without an adequate interval for recovery.[8] The AAP[6] and NATA[7] recommended counseling athletes who do specialize to take at least 3 nonconsecutive months off in 1-month intervals each year; furthermore, the AAP advised young athletes to take 1 to 2 days off per week to ensure adequate recovery. These athletes should also discuss their sport aspirations with appropriate personnel and assess the practicality of these goals.[5]

The AAP,[6] AMSSM,[1] and AOSSM[5] endorsed delaying specialization until late adolescence. By this age, athletes have already honed the physical, psychological, and social skills necessary to effectively specialize in a single sport.[6] Although the recommended level of intensity was not specified, most organizations advised youth athletes to take more than 1 month off from their sport in a year, potentially pursue fewer weekly training hours than their age, and have a good support system both in sport and at home to reduce the psychological effects of intense training.

What Are the Risks Associated With Sport Specialization?

An expanding body of primary scientific literature has explored the associations between youth sport specialization and an increased risk of overuse injury (Table 2). Before 2015, primary research consisted largely of smaller cross-sectional or survey studies, which may have been susceptible to recall and observer bias. These investigations typically focused on a single sport, age demographic, or injury type; a few focused on several categories. However, the results began to guide clinical recommendations and inform more recent research involving larger prospective surveys and active surveillance epidemiologic studies.

Risk of Overuse Injury

Since the introduction of the Jayanthi scale[18] in 2015, the authors of 8 of 10 identified studies (Table 2) used some or all components—year-round training (more than 8 months),

choosing a main sport, and quitting all other sports to focus on 1 main sport—to describe the degree of sport specialization. Sport specialization is then categorized as *low* (0 or 1 criterion), *moderate* (2 criteria), or *high* (3 criteria). Despite the methodologic limitations of some of the existing research, consistent findings have linked high degrees of sport specialization with higher rates of injury, particularly overuse injuries. These self-reported injuries included strains, Osgood-Schlatter disease, patellofemoral pain, and Sinding-Larsen-Johansson syndrome. Additionally, *serious overuse injuries* are typically defined as those that result in the loss of 1 month or more of playing time or participation. These include spondylolysis, osteochondritis dissecans, elbow ligament injuries, and stress fractures. Serious overuse injuries have been noted more frequently in specialized youth athletes in individual sports,[22] with a high degree of sport specialization adjusted for hours of training and age,[13,18] and participating in more hours of sports per week than their age in years.[13,18]

Acute Injury Risk

Paradoxically, researchers have shown no link between a high degree of sport specialization and acute injury risk. Furthermore, a ratio $>2:1$ hours per week (adjusted for age and hours training in sports) of organized sports to free playtime may be associated with a reduced risk of acute sports injuries.[18] This may reflect the sport selection: specialized athletes may be more likely to participate in individual sports, which carry a greater risk of overuse injury. On the other hand, team-sport athletes may be more likely to have acute, traumatic injuries and be less specialized.[22] Improved sport-specific skills and movement patterns in specialized young athletes may protect them from acute injuries despite perhaps placing them at higher risk for overuse injury due to increased training volumes.

Sport Type and Regions of Injury

Lower extremity-dominant sports such as basketball and soccer have been studied most frequently, but mixed and upper extremity-dominant sports (eg, baseball, tennis, volleyball) have also been addressed. In summary, risk factors such as playing on more than 1 organized team, engaging in competition (not just training) year-round, participating in more hours of sports per week than one's age in years, and a high degree of sport specialization have consistently been found to increase young athletes' risks for lower extremity pain and overuse injuries.[3,13,21] Additionally, overuse injuries to the lumbar spine may include more serious injuries that are typically seen in specialized athletes.[18] In studies focusing on baseball, pitching for multiple teams, pitching year-round, playing catcher in addition to pitching, and pitching on consecutive days were all associated with arm pain.[24,26,32] Pitching with arm pain was more closely associated with pitching-related injuries.[26] Logically, lower extremity overuse injuries are more common in running and repetitive lower extremity impact sports than in overhead sports, where upper extremity overuse injuries predominate.

Sex Differences

Few investigators have thoroughly explored sex differences with regard to sport specialization and overuse injuries in young athletes. The largest study to date, by Post et al,[3] indicated that, in a cohort of 1544 high school athletes, girls were more likely to have higher participation volumes, be active on club sports teams, and be highly specialized. Considered with other sport-specialization literature, these factors may place them at increased risk for overuse injury. In another study,[33] young female athletes were more likely than young male athletes to demonstrate increased risk for overuse injuries. This may reflect the choices of young female athletes to be involved in more individual, technical sports (eg, dance, gymnastics, tennis).

Sport Specificity

Because different sports have different risk profiles, the activity in which a young athlete specializes and the level of specialization are important when predicting injury risk. In a recent case-control study,[22] young athletes who engaged in individual, skill-specific sports (such as dance, gymnastics, or tennis) were more likely to be highly specialized at younger ages than those who participated in team sports. They had high training volumes on average and 1.67 times greater odds of developing an overuse injury than nonspecialized athletes, indicating that these individual sports may portend a worse overuse injury risk than team sports. Furthermore, individual sports have been examined to determine sport-specific injury risks. Among 540 United States Tennis Association junior tennis players, injury in the previous year and practice volumes were associated with the risk of withdrawing from a match for medical reasons.[34] This association disappeared after the authors adjusted for the age of specialization, indicating that it was closely linked to training volumes and confounded the relationship between training volumes and the risk of match withdrawal due to injury. Other sport-specific injury rates have also been investigated, with associations noted between knee overuse injury and playing on multiple soccer teams[21] as well as training more than 8 months per year in basketball, soccer, tennis, or volleyball.[10,25] Baseball pitching more than 8 months per year conferred 5 times the odds of sustaining an elbow or shoulder injury that required surgery,[24] and pitching on multiple teams or consecutive days increased the odds of arm pain or tiredness, which in turn increased the odds of injury by up to 7.9 times.[27]

Psychological Effects

In addition to physical stress, the intense training inherent in youth sport specialization is also thought to affect an athlete's psychosocial wellbeing, although evidence-based research on this relationship is lacking.[6,9] Numerous factors have been postulated to account for this potential association. Intense training can lead to social isolation, which can impede the normal formation of an athlete's identity.[5] Intrinsic characteristics, such as perfectionism, and external factors, such as unrealistic expectations set by parents and coaches, can result in excessive psychological stress.[20] This can, in turn, lead to maladaptive coping

strategies, loss of motivation, mood disturbances, and ultimately burnout.[5] The AOSSM, FIMS, IOC, and NATA encourage life balance and a strong social support system involving family, coaches, and medical staff to minimize these adverse effects.[5,7,9,20] Furthermore, the IOC advocated for educational programs to help coaches strengthen their relationships and interpersonal skills when dealing with athletes.[20]

Socioeconomic Factors

Two groups[12,19] have evaluated parental SES and sports participation. This aspect is important because high levels of sport specialization may be cost prohibitive to families of lower SES. Parents reported median spending of $1500 per year on club sports, which may only be feasible for families with higher household incomes.[12] In fact, this finding was upheld in the later study,[19] which indicated that youth athletes from families with high SES described more serious overuse injuries than athletes from families with lower SES. This may be due to higher rates of sport specialization by children from families of higher SES, resulting in more hours per week playing organized sports, a higher ratio of weekly hours in organized sports to free play, and greater participation in individual sports. In fact, the athletes of lower SES participated in more weekly hours of physical activity than those of higher SES but had a lower rate of serious overuse injuries, possibly from more weekly hours of free play and lower rates of sport specialization.

Geographic Factors

The influence of geographic location (rural or suburban) on sport-specialization rates and sport-participation characteristics has been evaluated.[11] Bell et al[11] observed that suburban high school athletes were more likely than rural high school athletes to be highly specialized, participate in a larger number of competitions per year, play in a league outside of school, train in their primary sport more than 8 months per year, and play their primary sport for more than 16 hours per week.

Rates of sport specialization likely also differ based on broader geographic location, with warm-weather climates being more conducive to year-round sport participation than colder climates, but the evidence in this area is limited. High school pitchers in warm-weather climates pitched for an average of 9 months per year compared with 6 months per year for pitchers in cold-weather climates.[35]

Other Health-Related Effects of Sport Specialization

Although position statements[6,9] have theorized negative effects of sport specialization on various noninjury aspects of wellbeing and health, few data currently exist to support this claim. Among parent-child pairs of specialized tennis athletes, health-related quality of life (HRQoL) measures were obtained and accelerometers were used to determine levels of physical activity in both the parents and children.[36] Both the parents and children had relatively high rates of HRQoL and moderate to vigorous physical activity. Interestingly, the parents of multisport athletes were 4 times more likely to pursue physical activity with their children. In a separate qualitative study,[37] researchers found that parent-child dyads of specialized versus multisport young athletes all had relatively high HRQoL. Parents expressed concerns about sport specialization but generally did not influence their child's decision to specialize.[37] Additionally, those athletes with high HRQoL had supportive environments with less emphasis on winning and outcomes.[37] The overall benefits of sports sampling by high school seniors included academic success, better nutritional habits, and less likelihood of engaging in addictive behavior.[38]

In a recent study,[39] investigators evaluated the potential associations of sport specialization with daytime sleepiness in 647 youth athletes from a variety of sports. High levels of specialization were associated with higher levels of daytime sleepiness. Additionally, athletes who had sustained an overuse injury in the previous year or who regularly traveled out of state for their sport had greater daytime sleepiness than uninjured athletes or athletes who did not travel regularly.[39] Overall, the profile of an athlete at high risk for serious overuse injuries is a young female athlete in an individual sport who focused solely on that sport at 10 years old, who was highly specialized with year-round training (more than 8 months per year), and participated in more weekly hours than her age with limited free play. This young athlete would possibly miss some of the other health benefits of a diversified experience but might still have the potential for a high HRQoL if she had a supportive family and coaching environment.

CONCLUSIONS

Many pathways are available for young athletes to develop elite-level success, including specializing in a single sport versus engaging in a variety of sports. The authors[28] of a review of sport specialization summarized that most studies suggested that intense or specialized training should occur after age 12. A number of these studies were limited by smaller sample sizes, recall bias, lack of primary scientific evidence, and inconsistent definitions. Despite the potential negative injury and psychological effects of sport specialization, the perception may still be that it is worth the risk to attain the perceived benefits.

Injury Risk

Position statements from sports medicine organizations have generally been consistent in recommending against early sport specialization. Although many of these recommendations do not state the age when it can occur, the effects on performance, or the specificity of the sport involved, they generally recommend a multisport-sampling developmental pathway for young athletes. The potential risks of injury, burnout, and attrition are cited. These risks may be supported by a few investigators, but a less measurable outcome is the potential negative effect on sport participation. In addition to the perceived injury risk, overtraining, and less appealing nature of an intensive training environment, it is possible that youth participation has declined in various team and individual sports.[40]

Injury risk in young athletes may be attenuated by an intervention of serial online counseling using evidence-based recommendations.[39] The source of the reduction in injury risk was unclear, but many of the recommendations

originated from reputable sources, so adherence to evidence-based guidelines may help reduce injury risk.[1,7,18]

Perceptions of Sport Specialization

Despite growing evidence linking specialization and overuse injury, the trend toward early specialization seems to be driven in part by the perceptions of youth athletes, parents, and coaches. Surveys[23,29,41] of parents and youth athletes indicated that a desire to play at the collegiate or professional level was a major factor in the decision to specialize. This belief did not appear to be shared by youth sport coaches, as the vast majority reported that playing multiple sports during childhood was most beneficial for developing athletic ability.[31] Additionally, coaches appeared to be more concerned about specialization and more aware of the link between specialization and overuse injury than parents.[30,31] However, most coaches and parents were unaware of sport-participation recommendations for reducing the risk of overuse injury, highlighting the need for outreach to and education of those involved in youth sports.[30,31]

In general, most recommendations by sports medicine organizations and based on the current available evidence in clinical and community-based cohorts of young athletes discourage early sport specialization. It is not clear what the appropriate age or stage of development is for specialization, and these factors may need to be sport specific. The current evidence and recommendations do suggest an independent association of sport specialization with overuse and serious overuse injury risks (but not acute injury risk). Other factors play a role in potentially modifying this injury risk, including sex, geography, SES, and type of sport. Although sport specialization is associated with potentially negative psychological health consequences, long-term effects have not been adequately demonstrated, and some specialized athletes with supportive family and coaching systems may maintain a high HRQoL.

Future Research

Most of the research into sport specialization has been cross-sectional and performed in different populations. The association with injury risk has been demonstrated in clinical,[8] community,[13] and high school[3,4,10,25] populations. Additionally, the organizational guidelines and position statements on this topic tend to offer general youth sports recommendations. These may be beneficial for broad recommendations and may establish some training guidelines regarding sport specialization and preventing training-related overuse injury. However, in certain populations, particularly elite young athletes, sport-specific recommendations regarding the potential age of specialization, associated risks, and age for optimal performance must be developed. National sport-governing bodies, in addition to coaches in each sport, are more likely to adopt such measures. This method will allow investigators to meticulously gather data on specific sport activities and demographic groups, include performance-based criteria, and establish specific health-related consequences of sport specialization.

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