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When Is It Too Early for Single Sport Specialization?

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Over the past 15 years, there has been an increase in youth sports participation with a concomitant increase in early year-round training in a single sport. Many factors contribute to the desire of parents and coaches to encourage early single sport specialization, including the desire to give the young athlete an edge in competition, pursuit of scholarships, and potential professional status, and the ability to label a young athlete as elite at an early age. Despite these perceived advantages, some data suggest that early sport specialization does not lead to a competitive advantage over athletes who participate in multiple sports. Although the data are limited, there is some evidence that early sport specialization may put the young athlete at risk for overuse injuries. The focus of this review is to highlight the evidence regarding early sport specialization and risk for injury; discuss the risk factors for overuse injury in high-risk sports including ice hockey, swimming, gymnastics, and baseball; and discuss future potential research that would help define the risk of injury for young athletes who participate in early sport specialization.

Keywords: youth sports injury; stress fracture; overuse; gymnastics; swimming; ulnar collateral ligament

Youth activity levels in the United States today include extremes of inactivity versus overactivity in sports. On the low side of the spectrum are the adolescents with low activity levels who have early-onset obesity, hypertension, diabetes, and elevated lipid profiles that will eventually lead to early-onset cardiac disease and other diseases. On the high side of the spectrum are the youth who participate in sports year-round—with a focus on either a single sport or multiple sports. There is abundant evidence that both groups are on the rise.[10] Although there is no doubt that it is imperative to maximize healthy physical activities in the preadolescent and adolescent age groups, there is considerable controversy as to when, how, and why a young person should become a "single sport athlete." Single sport specialization has become more popular among many coaches and parents as a means for youths to achieve expertise in a single sport with more focus on higher levels of athletic achievement and less focus on the "fun" aspects of athletic competition. The purpose of this review is to summarize the evidence regarding early single sport specialization and the risk for youth injury in a sport-specific manner and to suggest areas where further research is needed to best assess the effects of single sport specialization.

YOUTH SPORTS PARTICIPATION AND SPECIALIZATION

An estimated 27 million US youths between the ages of 6 and 18 participate in team sports, and 60 million participate in some form of organized athletics.[11] In the United States, there has been an increase in sports participation across all age groups over the past 15 years. In 1997, 9% of children under the age of 7 participated in organized sporting activities, compared with 12% in 2008.[32] Similarly there has been an increase in high school sports participation across many sports including baseball, softball, soccer, tennis, and swimming.[39] Among specific youth sports organizations, approximately 2.3 million children play Little League baseball, 365,000 play softball, and over 600,000 play youth soccer. These all represent increases in participation compared with the year 2000.

It is considerably more challenging to determine the age and competitive level that define early sport specialization. Specialization has been suspected to have increased at the high school level, as evidenced by a study of high school athletic directors who reported an increased trend in sport specialization.[25] There is also evidence of early sport specialization in the increase in the number of year-round travel leagues for preadolescents and the increase in young Olympic athletes.[27] However, clear data supporting an increase in early sport specialization of younger athletes are not available at this time.

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TABLE 1
Evidence Regarding Early Sport Specialization to Achieve Elite Status[a]

Study	Sport	Athletes	Study Conclusions
Barynina and Vaitsekhovskii[5]	Swimming	Elite Russian swimmers	Swimmers who specialized before 11 years of age spent less time on a national team and retired earlier than late specializers.
Carlson[9]	Tennis	10 elite, 10 near-elite	Elite players began intense training and specialized later than near-elites (after 13 years vs 11 years).
Lidor and Lavyan[30]	Multiple sports	63 elite, 78 near-elite	Elite athletes were more likely than near-elites to begin intense training after age 12 and were more likely to have played more than 1 sport in their developmental years.
Moesch et al[38]	Multiple sports	148 elite, 95 near elite	Elite athletes began intense training at a later age vs near-elites. Near-elites has more hours of training at a young age (9-15 years).
Gullich and Emrich[20]	Olympic sports	1558 German athletes, elite and near-elite	Elite athletes began intense training and competition in their sport later than did near-elites. More elites participated in more than 1 sport from age 11 years than did near-elites.

[a]Adapted from Jayanthi et al.[27]

Why Specialize?

Over the past 20 years, there has been a shift in emphasis from youth-driven recreational sports activities to parent- and coach-driven skills development with an emphasis on achieving a high level of accomplishment in a single sport. The causes of this are multifactorial and include the increasing emphasis on sports accomplishment in society, financial rewards for elite athletes, and public perception of the value of elite athletic competition. Malcom Gladwell popularized the "10,000 hours" rule for achieving expertise in a particular skill set, a theory that was originally proposed for musicians but has since been extrapolated across multiple fields including surgery and athletic achievements.[17] Although parents are often the driving influence on the initiation of sports, multiple studies suggest that the coach is the primary driving influence on the decision to specialize in a single sport. As Jayanthi et al[27] describe, this may establish a fundamental early disconnect where the interests and goals of the parent and child are not the same as those of the youth coach who is focused on success in a single sport.

There is evidence that early specialization in music results in a mastery of an instrument over a predictable period of time. This intuitively makes sense: With the exception of a few musical geniuses, a vast majority of musicians achieved success by starting at an early age, specializing and increasing their participation, and having a dedicated full-time commitment to practice. The evidence for the contribution of early sport specialization to mastering of a particular sport is not as clear. It makes intuitive sense that early development of skill sets in sports such as golf, tennis, and gymnastics, where postpubertal size and strength gains are not as important (or are detrimental) may be beneficial, but there is not clear evidence for this in the available literature. Some studies have suggested that late specialization in a particular sport, defined as older than 12 years of age, may result in better athletic achievement than early specialization (Table 1). Gullich and Emrich[20] evaluated more than 1500 German Olympic athletes and found that the elite athletes specialized later and were more likely to have participated in more than 1 sport over the age of 11. Carlson[9] evaluated elite men's and women's tennis players and reported that elite players began intense training and specialized later than the near-elite group of athletes. Similarly, Lidor and Lavyan[30] evaluated 63 elite and 78 near-elite athletes across a variety of sports. They found that the elite group was more likely to begin intense training after age 12 and to have played multiple sports during the developmental years (<11 years of age). Moesch et al[38] performed an elegant study in high-level Danish athletes who participated in multiple different sports. The authors reported that at younger ages (9, 12, and 15 years), the elite athletes had spent less time in intense training than the nonelite athletes. However, by age 21, the elite athletes had accumulated more time in training in their main sport. The authors concluded that late specialization as the athlete reaches physical maturity might be more likely to result in elite status. However, some studies suggest that early specialization is helpful in highly technical sports. For example, studies in rhythmic gymnastics suggest that early development was helpful in achieving elite status.[26]

Despite these studies, there is little evidence either for or against early specialization in many sports that have a high level of early year-round participation in the United States and in which athletes are at risk for overuse injuries, including baseball, gymnastics, swimming, and ice hockey. Ideally, prospective tracking of youth athlete participation and injuries over time would help determine whether there is a time threshold for injuries and for the development of elite status.[53]

BIOMECHANICS OF YOUTH OVERUSE AND OVERLOAD INJURIES

Overuse sports injuries in youth athletes often relate to musculoskeletal and physiologic immaturity. The muscles,

ligaments, and bones of adolescents are not fully developed, leading to potential injury with repeated use. As adolescents progress through puberty, their bodies grow and mature. However, tissue maturation progresses nonlinearly and unequally.[23] Animal studies have shown that the strength of epiphyseal cartilage to oppose tibial load decreases during puberty.[6]

The altered musculoskeletal tissue characteristics can distort the normal biomechanics in adolescent athletes, increasing the risk of overuse injuries. For instance, the biomechanics of youth pitchers differs from that of adult baseball players.[36] Youth pitchers tend to depend on rotator cuff musculature and truncal rotation to throw a baseball, which in combination with excessive humeral torque, underdeveloped musculature, and open epiphyseal plates predisposes these athletes to rotator cuff tendinitis, shoulder instability, and humeral epiphysiolysis (Little League shoulder).[18,28,50]

Additionally, the strain posed by overuse in youth athletes can lead to injury later in life. In a biomechanics study, Stull et al[54] evaluated the kinematics of hip position in the ice hockey sprint in Peewee (age approximately 11 years) ice hockey players. The study found that these athletes initially externally rotate in abduction during the push-off phase and subsequently internally rotate through increasing hip flexion during the recovery phase. This position creates impingement of the femoral neck, which can lead to increased stress on the acetabular chondrolabral junction and the potential for labral tears and cartilage damage later in life. The investigators concluded that there may be training techniques to reduce this high-risk position that could lower the injury risk in athletes as they mature and increase in skill level.[54]

IS THERE EVIDENCE THAT EARLY SINGLE SPORT SPECIALIZATION IS A RISK FACTOR FOR INJURY?

Sport specialization is considered intensive, year-round training in a single sport to the exclusion of other sports. There is a concern that early single sport specialization may increase the rates of both overuse injury and psychological burnout, but this relationship has yet to be clearly demonstrated with the available literature.[11]

There is some scientific evidence that early single sport specialization is a risk factor for injury. A case control study of 1206 seven- to eighteen-year-olds demonstrated that over the course of 3 years, picking a main sport to focus on was an independent risk factor for injury even after adjustment for age and hours per week in total sports activity (odds ratio, 1.48; $P < .05$).[49] In the National Athletic Trainers' Association (NATA) 2011 Position Statement on Prevention of Pediatric Overuse Injuries, the evidence presented on delayed specialization section is rated C (recommendation is based on consensus, usual practice, disease-oriented evidence, or case series). The evidence on sport alterations (modifications) is rated B (recommendation based on inconsistent or limited-quality experimental evidence) or C and focuses heavily on baseball pitching.[56] Similarly, a recent review article concluded that overuse is the main cause of ulnar collateral ligament injury and that the increase in year-round baseball has led to the skyrocketing rate of youth ulnar collateral ligament injuries.[7]

TABLE 2
USA Baseball Recommended Pitch Count Limits

Age, y	Pitch Count Limits
Daily limits	
7-8	50 per day
9-10	75 per day
11-12	85 per day
13-14	95 per day
15-16	95 per day
17-18	105 per day
Weekly limits	
9-14	21-35 pitches = 1 day rest
	36-50 pitches = 2 days rest
	51-65 pitches = 3 days rest
	66+ pitches = 4 days rest
15-18	31-45 pitches = 1 day rest
	46-60 pitches = 2 days rest
	61-75 pitches = 3 days rest
	76+ pitches = 4 days rest

The scientific evidence that early single sport specialization has a negative effect psychologically (eg, documented burnout rates) is more abundant than the evidence that such specialization clearly increases injury rates. However, Hall et al[21] evaluated a large cohort (N = 546) of female basketball, soccer, and volleyball players in middle school and high school and compared anterior knee pain between athletes who specialized in a single sport and those who played multiple sports. The authors found that there was a small but significant increase in patellofemoral pain (1.5-fold, $P = .038$) in those athletes who specialized in a single sport. The authors concluded that early sport specialization in female adolescents is associated with an increased risk of anterior knee pain. Despite the overall lack of scientific evidence linking early single sport specialization to injury, sport governing bodies have instituted restrictions designed to reduce the rate of injury.

USA Baseball, despite now sponsoring a National U12 Team, instituted pitch count recommendations based on its expertise and a review of the literature (Table 2). USA Swimming reports competitive times for U-10 and does not appear to have any published practice limits; however, its rule book states, "With the exception of championship meets, the program in all other age group competition shall be planned to allow the events for swimmers 12 years and younger to be completed in four (4) hours or less for a timed finals session or in a total of eight (8) hours or less per day for a preliminaries and finals meet" (Rule 205.3 F 2013).[55(p67)] USA Cycling, which holds competitions from ages 10 and up, has gear ratio restrictions that are believed to help riders develop a good pedal cadence and reduce the risk of injury. None of these recommendations across sports are based on published evidence, nor is there published evidence that rates of injury have decreased with these limitations. For example, the increase in ulnar collateral injuries in baseball is well

TABLE 3
High-Risk and Low-Risk Overuse Stress Fractures in Adolescent Athletes

Location	High Risk	Low Risk
Hip/pelvis	Tension side femoral neck	Compression side femoral neck
Lumbar spine	Pars interarticularis stress fracture	Pedicle stress fracture; spondylolysis
Leg	Anterior cortical tibial stress fracture	Medial tibial stress fracture; fibular shaft stress fracture
Foot	Tarsal navicular stress fracture, fifth metatarsal stress fracture, sesamoid stress fracture	Second, third, and fourth stress fracture; cuboid stress fracture
Wrist	Distal radial physeal stress injury	

documented although pitch count recommendations were created in 2008.[8] Thus, although there is no clear evidence that single sport specialization is a direct risk factor for injury, the available evidence does support the idea that high levels of training for a single sport in adolescence do not improve overall achievement and may put the youth athlete at risk for injury.

DIAGNOSIS OF COMMON YOUTH OVERUSE AND OVERLOAD INJURIES

A central aspect of evaluating a youth athlete with an overuse injury is to obtain a thorough history of the athlete's training volume and overall level of participation. Many studies have demonstrated that higher training volumes have a direct relationship to higher overuse injuries (Table 3). For example, in youth baseball, pitching more than 100 innings per year resulted in a 3.5-fold increase in injury risk that resulted in time lost from competition in the 9- to 14-year-old age group. Physicians should also consider participation times outside of competitions that occur with private coaches, parents, and teammates and count these athletic exposures as part of the overall time spent in training. In female athletes, a menstrual history should be obtained, and an evaluation of diet in both female and male athletes is appropriate and helpful in the diagnosis of overuse injuries. The physical examination should be directed toward the area of the chief complaint. Although not all overuse injuries are the result of single sport participation at a young age, repetitive load is considered a risk factor for many overuse injuries. Several specific types of overuse injury are described below.

Stress fractures are likely the most common youth overuse injury and are often overlooked as "growing pains," bone bruises, and normal wear and tear. The risk factors for stress fractures are the same for adult and pediatric populations: Overuse, decreased caloric intake, and overtraining are the most common causes.[41,42] On physical examination, most stress fractures are tender to palpation or percussion, and therefore bony tenderness should elicit further imaging to determine the presence of a stress reaction or stress fracture. In early stress reactions and stress fractures, magnetic resonance imaging (MRI) may be the most helpful imaging study for a diagnosis.[35] In cases of chronic stress fractures, radiographs may demonstrate chronic changes suggestive of attempts at bone remodeling.

Stress fractures can occur at any location when there are increased loads in the body, with lower extremity stress fractures more common than upper extremity stress fractures (Table 3). High-risk stress fractures include those of the femoral neck, posterior spine, anterior tibia, and fifth metatarsal. Stress fractures of the spine usually involve the pars interarticularis (spondylolysis) and can be present in almost 50% of youth athletes who have low back pain.[37] Stress fractures of the foot are the most common stress fracture in youth athletes and can occur across the entire foot. Injuries of the calcaneus are the most common stress fractures in the foot, followed by the cuboid, talus, navicular, and fifth metatarsal.[44] Treatment of a majority of these injuries is with cast or boot immobilization followed by a return to activity.

Fortunately, the majority of stress fractures and stress reactions can be treated with rest, appropriate caloric intake, activity restriction, rehabilitation, and a supervised graded return to activity. In only a small subset of these injuries is surgery required to treat a chronic malunion or nonunion. Although there are no clear prevention strategies, limits on high-load activities, assessment of diet to improve caloric intake, and early recognition of the at-risk athlete are reasonable considerations for assessment of stress fractures in all youth athletes.[11]

YOUTH OVERUSE INJURY IN SPECIFIC SPORTS

Whereas some sports, such as football, have clearly defined seasons with relatively few athletes participating in a year-round program, many other sports increasingly have both in-season and out-of-season options. In addition, many sports offer multiple levels of competition, from local teams to regional and "all-star" teams that each require their own practices and games. Roald Bahr[3] has suggested that individual athletic talent is a "damoclean sword"—those who are the most talented at a young age are most likely to be selected by coaches and parents to specialize, and therefore these youth are put at greatest risk for injury. Several sports are highlighted below as examples of how sport specialization may lead to higher risk of injury.

Baseball

Baseball is the sport and pitching is the position that have received the most attention related to early single sport specialization; pitch count limitations based on clinical expertise have been available since 2006.[15,45] Much of

this publicity has been around "Tommy John" surgery, the reconstruction of the ulnar collateral ligament whose deterioration is tied to overuse injury. For pitchers specifically, there appears to be causality between overuse and injury. Little League baseball has structured programs that start at age 5. There is a transition in the distance of the pitching mound and base paths as the children age. Mandatory pitch counts are now routine in youth baseball and have become a factor in Major League games as well. Pitch counts were developed around 2001 when it became apparent that pitchers who threw more than 75 pitches in a game reported increased shoulder pain.[32] These pitch counts continue to be revised and refined, with the latest recommendations including limits on sequential days of pitching and the number of pitches thrown. Exploration continues as to the effect of the type of pitch being thrown for overuse injuries.

Despite the recommendations put in place by the sport governing bodies, the rate of reported ulnar collateral ligament injuries in youths has risen exponentially. Whether this is due to pitch counts being inadequate, not enforced, or not the cause or to an increase in diagnosis is hard to determine.[14] A cross-sectional study of 754 pitchers (9-18 years old) reported that 45% of the pitchers had no pitch count in place and more than 13% pitched more than the recommended 8 months in a 1-year period.[58] Similarly, studies have shown that the incidence of elbow pain in youth baseball players is between 20% and 30% for 8- to 12-year-olds, approximately 45% for 13- to 14-year-olds, and over 50% for high school, college, and professional athletes.[19] In perhaps the most illuminating study regarding the perception of elbow pain and surgery in youth baseball, Ahmad et al[1] reported that 31% of baseball coaches, 28% of players, and 25% of parents do not believe that pitch count is a risk factor for elbow injury. A similar percentage of baseball coaches, players, and parents do not believe that pitch type is related to elbow injury. In this study, 30% of baseball coaches, 37% of parents, 51% of high school athletes, and 26% of collegiate athletes also believed that ulnar collateral ligament reconstruction should be performed prophylactically on athletes without elbow injury to improve performance. Unlike many other sports, baseball has wide-ranging opportunities for youth to continue playing in college and minor league baseball, with over 100 affiliated minor league teams, making the early intense training and travel teams potentially more enticing and worth the injury risk to players. The position of catcher is also beginning to come under more scrutiny with increases in concern about home plate collisions and the long-term effects of squatting on the hip joint.

Gymnastics

Gymnastics is a year-round indoor sport that tends to occur in private clubs, and so participation is not dictated by the climate and families are already conditioned to paying for participation. Gymnastics requires a facility with equipment and coaches who can "spot" (assist an athlete with a trick); thus, it is likely that the coaches are former highly skilled gymnasts who are accustomed to long training hours, not simply parents who used to play the sport and are "helping out" at the lower levels of competition. These clubs also rely on year-round participation for maintenance of a successful business, and this benefits from athletes who participate in year-round training. Unlike athletes in other sports, gymnasts are always learning new skills with increasing difficulty that create different loads on the body. Original international rules allowed for Olympic participation at age 14, but since 1997 the rule has been age 16. Practice schedules that must incorporate time on multiple pieces of equipment (4 types for women and 6 for men) vary widely in reports but range from 9 to 32 hours a week depending on the level of skill and facility. Gymnastics is also different from other sports in that peak performance is felt to occur in adolescence or early adulthood; few elite gymnasts continue to compete past their early 20s, so all their skill development and training occur early on. In gymnastics there is structured competition available through USA Gymnastics at age 4, but it is not considered competitive until age 7. Several overuse injuries are common in gymnasts, and injury rates and injuries vary depending on the skill level of the athlete. Commonly reported overuse injuries are to the wrist and low back in female gymnasts and to the shoulder and elbow in male gymnasts. The differences in injury patterns are related to the differences in equipment used and key maneuvers that differ in their emphasis on flexibility versus strength. In young women for example, spondylolysis is a common finding that is hypothesized to be linked to back-walkover type skills. Wrist injuries including stress fractures and growth plate injuries are also commonly seen, as the upper extremity is a weightbearing joint in gymnastics. One retrospective study evaluating women gymnasts demonstrated that there were similar rates of acute and overuse injuries in 96 competitive gymnasts, and the majority of injuries were lower extremity soft tissue injuries.[43] Early studies of wrist pain were associated with training intensity and years in training.[12,34] The role of early training on physiologic factors in gymnastics was widely discussed and summarized by Malina et al,[33] who reported that growth and maturation do not appear to be related to gymnastics training. There is the unavoidable confounder, however, of gymnasts self-selecting for the sport, being shorter and lighter than the average athlete, thus making youth participation hard to link directly to early single sport specialization.

Ice Hockey

Although ice hockey is not traditionally thought of as a year-round sport in much of the United States, participation of youths in ice hockey is increasing, and athletes often participate in multiple levels of competition during the year. Although hip and groin strains have been reported as a leading source of injury among hockey players, there is growing evidence that femoroacetabular impingement (FAI) may be the primary source of hip and groin injuries in youth athletes. Philippon et al[47] performed a study of 61 asymptomatic youth hockey players where the alpha angle was assessed in multiple age groups and compared with skiers as a control population. The

authors found that hockey players had a higher alpha angle associated with cam-type impingement (>55°), and importantly, this incidence increased with age and athletic participation. Further, the elite-level athletes in the older age group (16-19 years) had a higher incidence of labral tears as documented by MRI. Although the individual number of hours training was not quantified, this is one of the few studies to clearly demonstrate that participation in youth athletics can lead to detrimental bony changes during growth. The authors concluded that high levels of participation in ice hockey can increase the risk for the development of cam-type hip impingement and hip labral tears. A similar study performed in Switzerland evaluated 77 elite hockey players with a questionnaire, clinical examination, and imaging.[52] At an average age of 16.5 years, 20% of the athletes had a history of hip pain and a positive impingement test finding. The alpha angles were higher in athletes with closed physes versus open physes (58° vs 49°, respectively; $P < .001$). Symptomatic athletes had higher alpha angles compared with asymptomatic athletes, and internal rotation was significantly decreased in symptomatic compared with asymptomatic athletes (17° vs 23°, respectively). Thus, FAI may represent an overuse injury from playing ice hockey at an elite level during childhood.

Swimming

Elite swimmers typically swim between 4 and 9 miles per day and often swim 11 months of the year beginning at 10 to 12 years of age.[24] Overuse injuries in swimmers can occur in both the sprint and distance events as well as in triathlons.[2,4] For most swimmers, freestyle and backstroke make up most of the training time and rely on repetitive overhead activity. Interestingly, a majority of swimmers believe that shoulder pain is a normal process of the training process. The pathologic process is hypothesized to be from a combination of external impingement and the development of generalized laxity, followed by insufficient rest and recovery. Youth swimmers in particular may be at risk because they have been shown to have increased external and internal rotation.[48] There have been limited studies focused solely on adolescent swimmers and injury risk. However, several investigators have studied injury risk in swimmers across a wide range of ages. Sein et al[51] evaluated 80 elite swimmers between the ages of 13 and 25 years, finding that 91% of the swimmers reported shoulder pain, 84% had positive impingement signs, and 70% had MRI evidence of supraspinatus tendinopathy. Although stroke preference did not correlate with injury and shoulder pain, both the number of hours per week and the weekly mileage were significantly correlated with supraspinatus tendinopathy and pain.

Individual risk factors for developing shoulder pain in swimming have been evaluated in multiple studies. Walker et al[57] evaluated a cohort of swimmers from 11 to 27 years of age and reported that those with both decreased and increased external rotation were at much higher risk for a significant shoulder injury. Multiple studies suggest that a previous shoulder injury is the most important risk factor for developing further shoulder injuries.[22,24,57]

Currently, the long-term consequences of shoulder pain in swimmers are unknown because no long-term studies have evaluated changes in the rotator cuff over time in competitive youth swimmers. Current guidelines for swimming should mimic guidelines for other sports, such that significant shoulder pain results in changes in training regimens.

TREATMENT OPTIONS FOR OVERLOAD AND OVERUSE INJURIES

A discussion of individualized treatment options for overuse injury is beyond the scope of this review. The majority of injuries that occur to athletes who are specializing in single sports at a young age are overuse injuries that are best treated with nonoperative management. Primary treatments include a period of complete rest of the injured area, physical therapy, an evaluation of mechanics, and a reduction in participation, with particular attention to following established guidelines for participation when they are available. An exploration of the cause of the injury is critical so that all possible adjustments are made to ensure that the injury does not become a chronic concern. Spondylolisthesis, tendinopathy, and stress fractures, all common overuse injuries, respond well to nonoperative treatment.[13] For example, Klein et al[29] performed a meta-analysis on nonoperative treatment of spondylolysis. The authors found that 83.9% of adolescents treated nonoperatively had a successful clinical outcome after at least 1 year, and bracing did not influence this outcome.[29] Injuries such as medial elbow strains in throwers and shoulder pain in swimmers should be treated with an initial trial of nonoperative management before surgery is considered.[16]

Operative Treatment

Operative treatment is occasionally indicated for these injuries but should not be taken lightly or considered the first treatment option for most overuse injuries. Specialized centers report an exponential rise in ulnar collateral ligament reconstructions—increasing from 18% to 31% of all the elbow reconstructions over 10 years.[46] Major reconstructive surgery, such as ulnar collateral ligament reconstruction, may necessitate the removal of an athlete from all activity for an entire year. The outcomes of ulnar collateral reconstruction overall are good but may be overrepresented in sports media. Elite athletes have a high rate of return to pitching, but not all athletes have the same access to subspecialty surgeons, athletic trainers, and specialized physical therapists.

Hip arthroscopy for FAI is becoming more frequently performed. It will be important to monitor whether the treatment is escalating because the technique is becoming more available, the ability to diagnose the injury is easier, or the incidence of injury is actually increasing. An evaluation of the demographic characteristics of athletes seen over a 3-year period showed that the largest group of

athletes receiving surgery for a variety of FAI complaints were between 15 and 22 years old.[40] Currently, the long-term outcomes of hip arthroscopy for bony impingement and labral tears in adolescents are unknown, and it will be important over the next decade to determine whether hip arthroscopy for these lesions can be considered "preventive" of early osteoarthritis of the hip.

FUTURE DIRECTIONS FOR RESEARCH DIRECTED ON SINGLE SPORT SPECIALIZATION AND YOUTH SPORTS INJURIES

Research on the risks of single sport specialization in youth athletes is increasing, leading to a greater understanding of the determinants of overuse injuries. While sport-related injuries such as Little League shoulder or FAI in hockey players have been reported, further research is needed to determine other injury patterns in youth athletes and their long-term consequences. It is also important to identify at which age range sport specialization is clearly detrimental and when sport specialization becomes beneficial to the elite athlete. Biomechanical studies are necessary to determine the risk of improper form on soft tissue or bony overload in a specific sport. Additionally, laboratory studies are needed to understand the changes in musculoskeletal tissue properties during adolescence. Future clinical studies should focus on prospectively tracking the long-term implications of single sport specialization for individual joints and for different youth age groups, the difference in long-term injury prevalence associated with single sport specialization compared with multisport participation, and the effect of early training on proper form and mechanics. Finally, it is also increasingly important to educate parents, coaches, trainers, and physicians on the risks of early sport specialization and the early signs of injury to prevent more serious injuries that would limit the participation of competitive athletes.

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