

Common causes, concerns, and coordinating for a cure

Causas comunes, preocupaciones y coordinación para una cura

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Reception day: 28th of March , 2011

Acceptance date: 20th of June, 2011

ABSTRACT

The dramatic rise in organized sports participation by the young athlete has been met with an increase in significant acute and overuse injuries. The empiric observation that children and adolescents in our modern society are confronted with fewer physical stresses than their parents or grandparents is contrasted with the increasing specificity of stresses that are placed on them during current sports and athletic training activities. Children today may have less resilient and weaker muscle-tendon units and therefore face double jeopardy when confronted with specific, intense physical challenges that apply repetitive stress to unprepared tissues. There are physical and physiological differences between children and adults that may cause children to be more vulnerable to injury. Many factors contribute to these differences, including the growth process itself, vulnerability of growth cartilage to stresses, and strength and complex motor skill deficits. During times of rapid growth muscle strength and flexibility imbalances predispose the young athlete to injuries that are significant and possibly contribute to lifelong deficits. It is the objective of this lecture to review common pediatric sports injuries presenting to the clinician. A multidisciplinary team is required to address the unique needs of this expanding population. The future of pediatric sports medicine is injury prevention. Education with regard to early intervention is the key to success.

Key words: pediatric, sports injuries, motor skill deficits, injury prevention.

RESUMEN

El aumento de la participación de los niños y jóvenes en las competiciones deportivas ha llevado a un incremento paralelo de la incidencia de lesiones por sobre uso en este grupo poblacional. Las observaciones empíricas de que los niños y adolescentes de hoy en día realizan menor nivel de actividad física respecto de sus padres y abuelos contrasta con el incremento progresivo del estrés específico causado por las actividades deportivas actuales. Los niños de hoy han mostrado tener menor capacidad de recuperación y un sistema musculoesquelético más débil y por lo

tanto con mayor riesgo de dañarse cuando se les somete a la realización repetida de actividades específicas intensas. Existen diferencias físicas y fisiológicas entre niños y indolentes que hace que los primeros sean más susceptibles de lesionarse. Muchos factores contribuyen a la existencia de estas diferencias, incluido el proceso de crecimiento en sí mismo, la vulnerabilidad del cartilago de crecimiento, las deficiencias de fuerza y insuficiente la capacidad para realizar habilidades motoras complejas. Durante los periodos de rápido crecimiento, los desequilibrios en la fuerza muscular y la flexibilidad predisponen a los deportistas jóvenes a sufrir lesiones de gran importancia que puedan determinar un déficit motor que permanezca durante toda la vida. El objetivo de este artículo es revisar las lesiones más habituales que el médico clínico observa en niños y jóvenes deportistas. Un equipo multidisciplinario es necesario para atender las necesidades de esta población específica. El futuro de la medicina deportiva pediátrica es la prevención de lesiones siendo la educación para realizar una intervención temprana la clave para alcanzar el éxito.

Palabras clave: pediatría, lesiones deportivas, deficiencias en las habilidades motoras, prevención de lesiones.

INTRODUCTION

It is evident that we are in the midst of dual epidemics occurring in parallel. The epidemic of pediatric sports injuries and the epidemic of childhood obesity. Though innately very different, the treatment and prevention may in fact be very similar, that is individualized and directed strength and conditioning training. In the case of the young child "athlete", the goal is to prepare their skeletally immature bodies for early competitive sports participation to ultimately prevent injury. In the case of the young sedentary child, the sister goal is to arm them with the fundamental motor skills to confidently and successfully engage in physical activity. The final goal for the two groups is the same, to promote long term health and physical fitness.

In the sports medicine clinic at the Children's Hospital Boston, Massachusetts, USA, sports injuries in young skeletally immature children are being seen with increasing frequency and severity. Sports injuries in children and adolescents are the most common cause of musculoskeletal injuries treated in emergency departments in the United States, accounting for 41% of all musculoskeletal injuries. (Damore et al., 2003) This is in part due to the rapid growth of children involved in organized sports and fitness activities. Also, there is now a realization that children are sustaining serious injuries at young ages that may very well affect their long term health prompting early evaluation. Lastly, diagnostic modalities have improved significantly, with no or minimal risk to the young child, improving greatly our ability to make an accurate diagnosis and provide treatment in a timely fashion.

COORDINATING FOR A CURE

In order to successfully diagnose and treat the array of pediatric sports injuries seen on a daily basis, a multidisciplinary team of specialists, with an in depth knowledge base of pediatric anatomy, physiology, and

pathology is required. Our team is comprised of pediatric sports medicine physicians with a variety of primary care backgrounds including but not exclusive to, pediatric emergency medicine, internal medicine, and family medicine. Uniquely, sports medicine orthopedic surgeons work closely with non operative primary care sports medicine physicians to provide comprehensive care to young athletes. Essential to our practice is the collaboration of physicians, pediatric exercise physiologists, physical therapists, nutritionists, podiatrists, and psychologists. Without the unique contributions and specialized training of each member of the group, delivery of quality care would be difficult and possibly compromised.

COMMON PEDIATRIC SPORTS INJURIES

The increase in youth sports participation has been met with an increase in both acute macro traumatic and sub-acute or chronic micro traumatic injuries. These micro traumatic injuries often referred to as "overuse" injuries in the literature result from chronic repetitive injury to tissue over an extended period (Micheli, 1983).

A relatively common class of overuse injury encountered in children involve the traction apophyses at the insertion of the tendo achilles, or patellar tendon. Osgood-Schlatter disease (OSD) is a condition found in athletes who are rapidly growing, leading to an increase in tightness in muscle-tendon units. The patella tendon is subject to significant biomechanical forces due to its attachment to the strong quadriceps muscles proximally. This leads to repetitive strain at the attachment site of the tendon on the tibial apophysis resulting in a traction apophysitis. Osgood-Schlatter disease (OSD) and Severs Apophysitis are the most well known of the overuse syndromes involving the traction apophyses. The etiology of OSD is controversial in the literature, although a multi-factorial com-

ponent tends to be agreed upon. Osgood-Schlatter disease is a very common cause of anterior knee pain in the young athlete. This benign condition should be suspected in athletes who present at an early age with pain, swelling and tenderness at the anterior tuberosity of the tibia. Discomfort is usually generated with sports that entail significant running, jumping, and kicking. Weakness of the quadriceps and pain on resisted knee extension are common signs (Antich, Brewster, 1985). In the differential diagnosis of OSD, included in the same age range, are patellar peritendinitis, patellar apicitis (jumper's knee) and Sinding-Larsen-Johanson disease. Small avulsion fractures of the tibial tuberosity can also be confused with OSD. Osteogenic sarcoma of the proximal tibia and osteomyelitis of the tubercle should always be on the differential diagnosis list.

When evaluating a young athlete with complaints of knee pain we assess for risk factors in order to determine the cause. Training errors, musculotendinous imbalance, anatomic mal-alignment, improper equipment and growth, in particular, the growth spurt, are included in this list. Growth appears to have a two-fold role in the occurrence of children's overuse injuries. There is evidence that growing articular cartilage is less resistant to repetitive micro-trauma than adult cartilage. (Micheli, 1983) The traction apophyses are the site of overuse injuries in OSD as well as Severs Syndrome of the os calcis.

Calcification of the tibial apophysis begins in the distal part at the average age of 9 years in girls and 11 years in boys. The separate ossification centers of the tibial tuberosity fuse at the average age of 12 years in girls and 13 years in boys. There is increasing evidence that these syndromes are the result of tiny avulsion fractures and the body's resultant healing processes. These conditions are usually associated with tight muscle-tendon units in the affected child. (Ogden and Southwick, 1976)

The second aspect of growth as a risk factor indites the growth process and its subsequent effect on the tissues at risk. During periods of rapid growth-the growth spurts, there can be a significant increase in muscle-tendon tightness about the joints. Loss of flexibility during the adolescent growth spurt has been well documented. (Micheli et al., 2000; Ogden and Southwick, 1976). The patella tendon is subjected to biomechanical forces resulting from its attachment to the quadriceps muscle proximally and the patellar tendon distally. During periods of rapid growth, the tibial tuberosity is susceptible to repetitive strain from the tight quadriceps muscles.

The classic patient with OSD is a 13 or 14 year old boy who has undergone a rapid growth spurt in the preceding year (Kujala, 1985). Over the past years we

have seen a new population of athletes presenting with OSD. These are younger females, aged 10 or 11 years, involved in vigorous jumping training, as in figure skating or gymnastics. The presentation of these overuse injuries in the female population requires more investigation given the rise of the young female competitive athlete.

SALTER HARRIS FRACTURES (GROWTH PLATE FRACTURES)

The most significant difference between pediatric and adult fractures is the presence of the growth plate in the long bones of children. Growth plate injuries are classified according to the Salter Harris system. The majority of fractures in children and adolescents are Salter-Harris types I and II growth plate injuries. Salter Harris type I fractures occur most commonly in patients up to 5 years of age, whereas Salter-Harris type II fractures occur in patients older than 11 years of age. (England and Sundberg, 1996) Separation of the distal radius physis is the most common growth plate injury. (England and Sundberg, 1996) The prognosis with regard to growth arrest for these injuries worsens with injury type. Salter Harris type I and II injuries are generally benign and are associated with a lower risk for growth arrest than the other types of injuries.

Table 1. Salter Harris Fracture Types

- **SALTER-HARRIS I** epiphyseal separation through the physis; may or may not be displaced; if undisplaced, the radiographs may be normal
- **SALTER HARRIS II** a triangular fragment of the metaphysis remains attached to the epiphysis (Thurston-Holland sign) with the separation also through the physis
- **SALTER HARRIS III** physeal separation that passes through the epiphysis and into the joint; this leads to an intra-articular fracture; possible joint incongruity may occur if not anatomically reduced.
- **SALTER HARRIS IV** fracture passes through the metaphysis, growth plate, and epiphysis and into the joint; as with type III injuries, an anatomic reduction is necessary for continued growth and joint congruity
- **SALTER HARRIS V** (can be diagnosed only in retrospect) a compression injury of the physis that may lead to permanent injury.

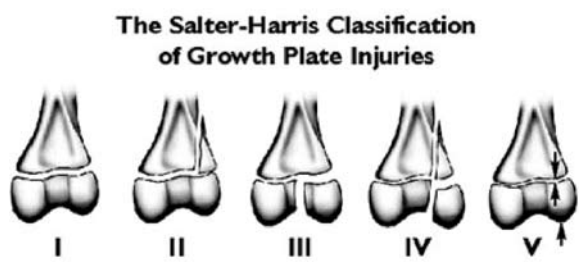


Figure 1. Growth Plate Fracture Classification

ANTERIOR CRUCIATE LIGAMENT INJURIES IN THE YOUNG ATHLETE

Among young athletes, the incidence of anterior cruciate ligament (ACL) injuries appears to be increasing in epidemic proportions, with increased sports participation. For this reason injury to the ACL of the knee in sports has received increased attention over the past few years. Investigators have noted a high incidence of ACL injury in sports such as basketball, soccer, field hockey, lacrosse, and handball, all of which require rapid change in direction, pivoting, and deceleration maneuvers. Additional clinical observations about these non-contact injuries demonstrates a high occurrence among adolescent athletes, in particular young female athletes. The role of gender in ACL injuries has received much attention in the literature, with the primary focus on college and or professional level participation. There is reportedly an increased predisposition (two to eight times) of ACL rupture in women. Theories include joint laxity, hormonal influences, limb alignment, notch dimensions and ligament size. (Harmon and Ireland, 2000).

Although the true incidence of ACL injury among athletes is not known, ACL injuries commonly result from sports participation. In a study of Norwegian soccer players over a 9-year period, Bjordel et al found that the incidence of ACL injury was higher among female athletes and higher in upper division levels of competition. A significantly increased risk of noncontact ACL injury has been noted in female soccer and basketball athletes when compared with male athletes in the same sports (Arendt et al., 1995). NCAA data has shown that females have a 2.89 increased risk of ACL injury in basketball and 2.29 increased rate in soccer. (Ireland, 1999). Though injury rates are high in females for both acute injuries including ACL rupture and overuse injuries like patellofemoral pain complex, the benefits of sports participation for the young female are many and worth noting. These include promoting greater confidence and self-esteem, demonstration of decreased risk of high risk behaviors including cigarette

smoking, and increasing the likelihood of experiencing academic success.

Factors contributing to ACL injuries can be classified into three categories; intrinsic or not controllable, extrinsic or controllable, or partially controllable (Table 2). (Ireland, 1999) The best and most productive way to reduce ACL injury rates is to focus energies on factors that can be modified. These factors include development and enhancement of playing style, physical preparation /neuromuscular control, and skill acquisition. (Ireland, 1999) Physical preparation for skilled sports participation may be most effective if initiated when the child is very young.

Table 2. Factors Contributing to ACL Injuries

- Intrinsic (Not controllable)
 - Alignment
 - ACL size
 - Femoral notch size and shape
 - Hormonal influences
 - Inherited skills and coordination
- Partially Controllable
 - Proprioception (position sense)
 - Neuromuscular activation patterns
 - Order of muscle firing
 - Acquired skills
- Extrinsic (Controllable)
 - Strength
 - Conditioning
 - Equipment/environment
 - Motivation

(Source: Ireland, M.L. Journal of Athletic Training 1999)

ACL injuries in skeletally immature athletes pose unique challenges, namely ligament reconstruction through an open growth plate or physis and concordant cartilage injury/meniscal tear. Kocher reported in 2004 at American Academy of Orthopaedic Surgery on associated injuries in skeletally immature patients with ACL tears. He found 99 consecutive ACL tears with a mean age of 14.2 years. Meniscal injuries were seen in 49% (49/102) of the injuries.

Medical management of these injuries can be challenging as these injuries often occur in the most active of children. Initial attempt is made to treat non operatively in the absence of instability and cartilage/meniscal tear. This treatment is often very challenging, as the mainstay of treatment is activity limitation and bracing. Non operative treatment of complete tears typically results in recurrent instability and injury to the meniscus or articular cartilage. Janary et al. examined

twenty-eight consecutive, skeletally immature patients (9.9-15.0 years of age at the time of injury) with total rupture of the ACL. Mean follow up was 3-5 years. The aims of the study were to monitor the natural course of conservative treatment and to identify variables relevant to failure of conservative treatment. Sixty-eight percent of the patients treated conservatively were operated on at follow-up. The patients not operated on were younger at injury and had a lower activity level at follow-up. The surgical procedure improved objective and subjective knee function though there was a correlation between high activity level and a low Lysholm score.

The surgical approach to the young athlete who has ruptured their ACL is fraught with concerns. The conventional adult type ACL reconstruction risks iatrogenic injury to the growth plate and subsequent growth disturbance of the long bones of the lower extremity. Surgical technique is based upon skeletal maturity and the amount of growth remaining (Figure 1). If the decision is made to move forward with surgical ACL reconstruction skeletal age must be determined. In the prepubescent skeletally immature patient a physal sparing ACL reconstruction is performed using an autogenous iliotibial band graft. This surgery was initially thought to be temporary until skeletal maturity is reached, when an adult reconstruction can be safely performed. Recent studies by Kocher et al have been surprisingly promising with regard to long term outcome. He found that in 44 patients with this type of reconstruction the revision rate was 4.5% with a mean age 10.3 years and a mean follow up of 5.3 years. Importantly no growth disturbance was seen. (Kocher et al., 2005) Thus at this time it appears that physal sparing ACL reconstructions in the very youngest of athletes provides for excellent functional outcome and low revision rate or need for future surgery.

STRESS FRACTURES OF THE SPINE SPONDYLOLYSIS AND SPONDYLOLISTHESIS

The spine is at increased risk for injury in the growing athlete. Elite gymnasts can begin as early as age 4 and spend up to 50 hours per week practicing and competing (Colvin and Lynn, 2010; Gabel, 1998) placing them at significant risk for injury. The adolescent spine differs from the adult spine in many ways. First, there is an abundant presence of growth cartilage. This growth cartilage is vulnerable to injury as it is the attachment site of spinal soft tissue. As stated earlier in the text, the soft tissue traction on vulnerable growth cartilage of spine (apophysis) may become problematic in the young athlete who participates in sports requiring repetitive flexion and extension. Second, the adolescent growth spurt promotes muscle tightness

of the hamstrings, hip flexors and quadriceps muscles. This lower extremity muscle tightness contributes to an increase in lumbar lordosis (curvature of the lower back) which places an increase stress on the posterior bony elements of the spine.

Injury patterns of the spine differ significantly in athletes versus non athletes. Micheli (1995) investigated back injuries in athletes as compared to non athletes. Non athletes were found to have a higher incidence of degenerative arthritic conditions and a significantly higher rate of discogenic back pain (48%) versus athletes (11%). Young athletes with back pain were found to have spondylolysis in 47% versus the adult population with back pain (5%). (Micheli, 1995)

Spondylolysis is a fracture or break of the pars interarticularis. This vulnerable bony bridge is located in the posterior column of the spine. Injury results from repetitive hyperextension and rotation to the lumbar spine. Hyperextension sports with a high risk of injury include ballet, gymnastics, figure skating, volleyball, diving and American football. Spondylolysis has been shown to have a familial association (Loud, 2005).

Physical examination of an athlete with spondylolysis often reveals pain with provocative testing including standing hyperextension and the stork test. The stork test elicits symptoms with one-legged hyperextension when the patient is standing. The high risk athlete with low back pain and a positive physical examination warrants further investigation and treatment. Diagnostic modalities include plain radiographs, CT scan, MRI, SPECT bone scan. Treatment options include relative rest, physical therapy directed at correcting muscle strength and flexibility imbalances and building core strength. Anti lordotic bracing for 4 months is used in our institution. Between 1988 and 1995, 73 adolescent athletes treated with the Boston Overlap Brace for spondylolysis were reviewed to evaluate improvement in pain score and activity level. A favorable clinical outcome was achieved in 80% of the patients evaluated. (D'Hemecourt, 2002 and Steiner and Micheli, 1985) Return to sport may occur as early as 4-6 weeks if the athlete is asymptomatic and compliant with bracing.

JUVENILE OSTEOCHONDRITIS DISSECANS

A common overuse injury presenting to our sports medicine clinic is osteochondritis dissecans (OCD). OCD is a pathologic condition affecting cartilage and subchondral bone and is characterized by osteochondral fragment separation from the vascular bone bed. OCD is a disease spectrum from cartilage softening, to breach in cartilage, to partial detachment, to separation with loose body formation. OCD is classified into two main categories based on skeletal maturity. The

prognosis differs greatly depending on the class. Juvenile osteochondritis dissecans (JOCD) begins prior to closure of distal femoral physis. If diagnosed early and treated effectively the outcome is quite good. The epidemiology includes an incidence of 18-29 per 100,000 reported by Linden 1976. The true prevalence is unknown due to ever growing youth sports participation across genders, loss of free play, early sports specialization or multiple league involvement. The prevalence among females is increasing (Cahill, 1995) reflecting the increase in female sports participation. The average age of JOCD is decreasing (Cahill, 1995) likely reflecting the younger age of competitive sports participation, earlier recognition and better diagnostics.

The etiology of osteochondritis dissecans has been debated over the years.

Fairbanks 1933 first described the etiology as traumatic in origin, as a result of a "violent rotation inwards of the tibia, driving the tibial spine against the inner condyle. Ribbing 1955 described the etiology as an ossification abnormality. Two other etiologies include inflammation and ischemia both have not been proven in the literature. A genetic predisposition was disproven by Petrie 1977 who identified only 1 of 86 first degree relatives. At present the common form of OCD is not thought to be familial. It seems to be agreed upon by experts that the disease involves a dynamic process including repetitive trauma causing initially a bony stress reaction followed by stress fracture or disruption of the bone. If persistent micro trauma continues healing mechanisms are overloaded leading

to bony necrosis with ultimate fragment dissection and separation and eventual bony nonunion. (Kocher et al. Med 2006)

Diagnoses considered when the pediatric sports medicine physician is faced with a young athlete with atraumatic knee pain include patellofemoral pain, synovial plica, Osgood Schlatter Disease, patellar tendinitis, OCD, and importantly 'other' categories including systemic processes like juvenile arthritis, oncologic etiologies, and complex regional pain syndromes.

Diagnosis can be challenging for the physician in that the clinical presentation is often nonspecific with poorly localized pain that is often exacerbated by exercise. Physical examination may reveal an antalgic and externally rotated gait and localized tenderness of the anterior knee. Unstable lesions are almost always symptomatic with mechanical symptoms, crepitus, pain with motion, effusion and quadriceps atrophy.

Management is controversial including initial non operative treatment for lesions that are deemed as stable. Bracing/casting and activity modification are employed. Treated conservatively 50% of lesions may heal. (Cahill, 1989 and Pill, 2003)

TAKE AWAY POINTS

Children are not little adults unique anatomic and physiologic concerns exist. The professional caring for the young athlete should be well versed in the early recognition and treatment of pediatric sports injuries. Injury prevention is lacking and is the future of pediatric sports medicine.

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