

A GROWING ISSUE OF OVERUSE INJURIES IN YOUNG ATHLETES

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ABSTRACT

Over the past two decades, participation in professional sports among children and adolescents has surged despite the rising inactivity and obesity rates. Approximately 60 million young individuals in the USA are involved in organized sports. This increase has led to a concerning rise in overuse syndromes, which is becoming a primary concern in sports medicine.

Our review aims to examine common overuse syndromes in youth athletes and assess risk factors, pathophysiology, and preventive measures. Early sports specialization, societal pressures, and competitive demands lead to repetitive strain injuries. The young musculoskeletal system, though adaptable, is prone to injuries from intense training and insufficient recovery.

Prevention advocates against early sports specialization and promotes adequate rest. Diversifying sports, limiting training hours, and a robust support system are recommended to counteract the mental effects of intense specialization.

In summary, a holistic approach is needed to address overuse syndromes, emphasizing diversification, education, and a balanced approach to sports.

Keywords: *adolescent athletes, early sports specialization, overuse syndromes, preventive measures, psychological well-being.*

NARAŠČAJOČA PROBLEMATIKA PREOBREMENITVENIH SINDROMOV PRI MLADIH ŠPORTNIKI

IZVLEČEK

V zadnjih dveh desetletjih se je udejstvovanje otrok in mladostnikov v profesionalnem športu močno povečalo, kljub splošno naraščajočemu deležu neaktivnosti in debelosti. V ZDA se z organiziranim športom ukvarja približno 60 milijonov mladih posameznikov. To povzroča zaskrbljujoče povečanje preobremenitvenih sindromov, pomembne patologije v športni medicini.

V tem preglednem članku obravnavamo preobremenitvene sindrome pri mladih športnikih, dejavnike tveganja, patofiziologijo in preventivne ukrepe. Zgodnja usmeritev v športu, družbeni pritiski in tekmovalne norme vodijo do poškodb zaradi ponavljajočih se obremenitev. Mladi mišično-skeletni sistem je sicer prilagojen na zmerno aktivnost, hkrati pa nagnjen k poškodbam zaradi intenzivnega treninga in nezadostnega okrevanja.

Preventivni ukrepi strmijo k preprečevanju zgodnje specializacije v športu in spodbujajo ustrezen počitek. Za ohranjanje mentalnega zdravja se priporočajo raznovrstnost športov, omejitev števila ur treninga in izdelan sistem pomoči.

Za obravnavo preobremenitvenih sindromov je potreben celosten pristop, ki poudarja diverzifikacijo, izobraževanje in uravnotežen pristop k športu.

Ključne besede: *športnik adolescent, zgodnja usmeritev v športu, preobremenitveni sindromi, preventivni ukrepi, psihološko zdravje.*

INTRODUCTION

Despite the rising rates of inactivity and obesity, the number of children and adolescents participating in organized or recreational athletics has increased significantly during the last two decades. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007) It is estimated that around 60 million children and adolescents in the USA participate in some organized sports activities. (DiFiori et al., 2014) Although there have been no similar studies on participation in sports in Europe, a recent study found increased participation among U8 – U14 for most sports. (Emmonds, Till, Weaving, Burton & Lara-Bercial, 2023) Since moderate sports activities positively affect physiological and psychological health, overly trained and improperly recovered adolescents are at risk of various overuse syndromes, which is a hot topic in sports medicine and orthopedic surgery. This study aims to provide a comprehensive overview of the overuse syndromes in adolescents, known risk factors, pathophysiology, and prevention techniques.

RISK FACTORS

Overuse syndromes in youth are becoming a growing issue due to a combination of societal, cultural, and technological factors. There are several key reasons that contribute to the increase in overuse syndromes among young individuals. (Shigematsu, Katoh, Suzuki, Nakata, & Sasai, 2022; van Poppel et al., 2021) Young and inexperienced athletes with lower fitness levels may be more susceptible, especially at the beginning of a training period. Poor technique may result in disproportionate stress on certain tissues, leading to fatigue, which may predispose people to overuse syndromes. (Brenner & Watson, 2024; Leppänen et al., 2017) Previous injuries, high body mass index, female sex, weekly hours in sports, and high-level competitions were found to be among the most substantial risk factors. (Shigematsu et al., 2022; van Poppel et al., 2021) Many young athletes are encouraged to specialize in a single sport from a very early age. Early sport specialization, specifically in sports with considerable biomechanical repetition, limits young people to a single set of activities that can lead to repetitive strain on specific muscle groups and joints that exceeds the healing capacity of the tissue, resulting in an increased risk of overuse injuries. (Brenner & Watson, 2024; Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007; Shigematsu et al., 2022;

Sweeney, Rodenberg, & MacDonald, 2020) It also prevents young athletes from developing advanced motor skills and diverse movement patterns. Studies have shown that participating in multiple sports activities correlates with fewer overuse syndromes in youth athletes. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007; Popkin, Bayomy, & Ahmad, 2019; Puzziello, Rizzo, Garvey, Matzkin, & Salzler, 2021)

The youth musculoskeletal system is an immature complex of bones, muscles, tendons, and ligaments that undergoes rapid growth and allows athletes to participate in various sports activities. However, growth-related changes make it vulnerable to acute and chronic injuries if exposed to excessive stress. (Aicale, Tarantino, & Maffulli, 2018) Unfortunately, modern training methods often involve high-intensity training regimens that push young athletes to their limits. Additionally, inadequate rest and recovery time between similar training sessions and muscle exercise can prevent the body from healing properly.

There's also a lack of adequate education about the risks of overuse injuries and the importance of injury prevention strategies, like proper warm-up, cool-down, and strength training. The desire to excel and competitive pressures from parents, coaches, and peers can drive young athletes to push themselves beyond their limits. (Brenner & American Academy of Pediatrics Council on Sports Medicine and Fitness, 2007)

PATHOPHYSIOLOGY

Traditionally, the absence of a single, identifiable traumatic episode has been used to define a causal element of overuse injury. An overuse injury involves microtraumatic damage to a bone, muscle, tendon, or ligament caused by repetitive stress that fails to heal or undergo the natural reparative process. (Aicale et al., 2018)

Apophysitis

Apophyses (also entheses), secondary ossification centers with tendon insertions, are vulnerable to strenuous forces applied through muscle contractions, causing repetitive microtraumatic lesions, inflammatory scar reactions, and ectopic ossifications. They are considered two to five times weaker than the surrounding structures, including the muscle-tendon complex, ligaments, and bones. (Kose, 2010) Inflexibility and bone spurts before muscle lengthen-

ing can both contribute to increased traction forces. (Yanagisawa et al., 2014) Apophysitis is known to have multifactorial origins, including growth spurts, genetic predispositions, and anatomic features. (Gudelis et al., 2022) Combined with repetitive overuse activities like running, jumping, and throwing, which exert traction loads on the entheses, an inflammatory and degenerative response in the apophyseal cartilage can subsequently result in an avulsion fracture. (Gudelis et al., 2022).

Tendinopathy

Overuse tendinopathy induces nociceptors and swelling in the afflicted tendon, weakening its load tolerance and function during limb exercise. (Abate et al., 2009; Rio et al., 2014) Most sports-related tendinopathies have well-defined degenerative histopathological lesions, which explains the chronicity of symptoms that typically occur in athletes with tendinopathies. (Aicale et al., 2018; Sharma & Maffulli, 2006) Although the precise sequence of the natural healing process in tendinopathic tendons remains obscure, a failed healing response results in the degeneration and proliferation of tenocytes, disruption of collagen fibers, and a subsequent increase in non-collagenous matrix. (Longo, Ronga, & Maffulli, 2009, Longo et al., 2007) Under chronic stress, such as diabetes mellitus or obesity, an acute inflammatory response is significantly altered, which is marked by the failed migration of inflammatory cells. Similarly, mechanical stress that results in chronic stress may also explain the development of tendinopathy. (Aicale et al., 2018) Although the data on its prevalence and incidence are scarce, it primarily affects female and male volleyball and basketball players. (Nutarelli, da Lodi, Cook, Deabate, & Filardo, 2023) However, it is more common in adults due to the fused apophyses, which are the weakest part of the osteotendinous junction in adolescents. (Benjamin et al., 2006; Nutarelli et al., 2023)

Stress Reactions and Juvenile Osteochondritis Dissecans

Stress reactions may be followed by insufficient bone healing, resulting in stress fractures. The bone's reaction to recurrent stress is enhanced osteoclastic activity over osteoblastic new bone formation, resulting in temporary bone weakening. (Fullem, 2015) Physiologically, the new periosteal formation is then stimulated. (Harrast & Colonna, 2010) If physical stress continues, osteo-

clastic activity may predominate, resulting in microfractures, and, ultimately, a real cortical break (stress fracture). (Chéron, Le Scanff, & Leboeuf-Yde, 2017) Various interrelated extrinsic and intrinsic factors contribute to an excessive load on bones. A primary risk factor is an increase in the frequency, duration, and intensity of training load. (Johanson, 1992) Hard training surfaces and shoes older than six months also contribute to less optimal shock absorption. Among the intrinsic factors, low bone mineral density (BMD), loss of muscle mass, and small calf girth are associated with a higher incidence of stress fractures. (Harrast & Colonno, 2010; Pohl, Mullineaux, Milner, Hamill, & Davis, 2008)

Repetitive microtrauma is also considered a significant cause of juvenile osteochondritis dissecans. (Pascual-Garrido, Moran, Green, & Cole, 2013) It weakens the subchondral bone, resulting in local necrosis and delamination, followed by an intraarticular loose body if untreated. It is a common cause of knee pain in adolescents, both athletes and non-athletes. (Kumar, Bhatnagar, & Lodhi, 2018) Although “ostochondritis” indicates the inflammatory process, histological results suggest no signs of inflammation. (Rothermich, Glaviano, Li, & Hart, 2015) However, the thorough etiology remains unclear. (Schulz & Chambers, 2013)

SPECIFIC CONDITIONS

Lower Extremity

Osgood-Schlatter and Sinding-Larsen-Johansson Disease

Traction apophysitis occurs on both sides of the patellar tendon. Osgood-Schlatter disease (OSD) affects the tibial tubercle, whereas Sinding-Larsen-Johansson disease (SLJD) is located under the inferior pole of the patella. The peak incidence for SLJD is at around 10 and 13 years, while OSD occurs at around 10 and 15 years when children undergo a growth spurt. (Patel & Villalobos, 2017; Yen, 2014) It is more common in athletes vs. non-athletes (21% vs. 4.5%, respectively). (de Lucena, dos Santos Gomes, & Guerra, 2011) Young volleyball and basketball players, jumpers, and runners are known to be at risk of apophysitis around the knee since these sports require repetitive jumping activity that exerts stress on the patellar ligament. (Itoh et al., 2018) In 30% of OSD, the disease presents bilaterally. (Circi, Atalay, & Beyzadeoglu, 2017) Diagnosis is usually clinical, with tenderness and swelling on either side of the

patellar insertion. Regarding OSD disease, conservative treatment is successful and symptoms typically disappear after the finish of growth. Given the benign nature of the disease, children are encouraged to continue with activities. (Circi et al., 2017) Conversely, SLJD disease requires more attention to stretch the hamstrings, quadriceps, and heel cord in combination with relative rest. (Valentino, Quiligotti, & Ruggirello, 2012) Symptoms can take up to 24 months to completely resolve, though pain usually doesn't persist after the fusion of apophysis. (Valentino et al., 2012)

Sever Disease

Sever disease or calcaneal apophysitis is a common cause of heel pain in youth athletes. (Ishikawa, 2005) It occurs at the insertion of the Achilles tendon into the calcaneus and is frequently worsened by running or jumping. (James, Williams, & Haines, 2013) Risk factors include a tight heel cord, running and jumping activities, and early sports specialization. (Elengard, Karlsson, & Silbernel, 2010) It is common among young basketball, volleyball, and football players. (Martinelli et al., 2019) Diagnosis is clinical, with tenderness over the calcaneal insertion. Pain management is conservative and stretching plays a vital role. (James et al., 2013)

Patellofemoral Syndrome

This represents one of the most common causes of knee pain in adolescents. It includes peripatellar and retropatellar pain that is exacerbated by specific positions and activities. (Calmbach & Hutchens, 2003) While traction apophysitis more often affects boys, patellofemoral syndrome is more common among female athletes. (Vora, Tien, Parks, & Schon, 2006) The reported annual incidence of patellofemoral syndrome among adolescents ranges from 3% to 40%. (Callaghan & Selfe, 2007) It is a common complaint in the active population, particularly in adolescent athletes who participate in jumping, cutting, and pivoting sports. (Halabchi, Abolhasani, Mirshahi, & Alizadeh, 2017) Although the exact etiology remains unknown, muscle imbalance, patellar instability, tendinosis of the extensor apparatus, and chondral defects may be involved in the pathogenesis. (Pavone et al., 2022) Also, early sport specialization in female adolescents is associated with an increased risk of patellofemoral syndrome when compared with multisport athletes. (Hall, Barber Foss, Hewett,

& Myer, 2015) Patients complain of anterior knee pain that worsens with running, squatting, and prolonged sitting (theater sign). (Patel & Villalobos, 2017) Popping, catching, or the sensation of their knee giving way may be among the complaints. Examination reveals poor quadriceps and hamstring flexibility, tenderness around the patella with a positive grind test, and weak hip abductors. (Sweeney et al., 2020) Although the diagnosis is clinical, an x-ray may reveal biomechanical abnormalities such as patellar tilt and patella alta or baja. (Patel & Villalobos, 2017) Management is conservative with activity modification and an emphasis on the improvement of knee biomechanics. (Dixit, DiFiori, Burton, & Mines, 2007)

Iliotibial Band Syndrome

Especially common among runners and cyclists, iliotibial band syndrome (ITBS), also known as runner's knee, involves pain around the lateral femoral condyle as the ITB passes over. (Sweeney et al., 2020) Predisposing factors are lack of stretching with a tight ITB, varus knee deformity, and overpronation of the feet with an excessive internal rotation of the legs, which increase the friction around the lateral femoral condyle. Diagnosis is typically clinical and requires no additional imaging. Treatment consists of conservative modalities such as activity modification, stretching, and NSAIDs. (Patel & Villalobos, 2017) A steroid injection in refractory cases is rarely used in youth populations. (Ellis et al., 2010)

Osteochondritis Dissecans (OCD)

Also known as König's disease, it most commonly occurs in the lateral part of the medial femoral condyle. Between 10 and 13 years, boys are affected significantly more often than girls (4:1). (Launay, 2015) It is characterized by mechanical pain that is difficult to pinpoint. The diagnosis is radiological with an x-ray, though an MRI is also usually performed to define the extent of the subchondral bone edema. In advanced stages, loose bodies can be found intraarticularly, limiting the range of motion and locking the knee. Treatment usually involves avoiding sports activities for six months, whereas partial weight bearing is allowed if pain is absent. Lesions smaller than 2.5 cm² have the greatest potential to heal through conservative methods. (Launay, 2015) Surgical

methods, such as microfracturing or osteochondral fixation, are reserved for advanced cases when conservative treatment fails. (Kreuz et al., 2006)

Similarly, OCD often occurs in the posteromedial aspect of the talus. Both ischemic and microtraumatic factors are believed to be involved in the process of the disease. It is common among boys over ten who participate in court-based sports such as volleyball and handball. (Launay, 2015) The symptoms, diagnosis, and treatment are similar to König's disease.

Upper Extremity

Little Leaguer's Elbow

Baseball players are among the most at risk of medial epicondyle apophysitis, also known as little leaguer's elbow. Between 20 and 40 % of youth pitchers suffer from thrower's elbow. (Otoshi et al., 2017) High pitch counts in each game, pitching on many teams, coach-driven incentives to throw harder, the use of a radar gun to monitor speed, and not taking enough time off from the sport during the year are all risk factors. (Norton et al., 2019) The act of throwing produces traction force on the medial epicondyle physal plate, which results in tenderness in the medial epicondyle. A specific provoking test is the "milking maneuver", performed with resisted flexion/pronation with valgus stress. (Norton et al., 2019) Usually, conservative treatment suffices. However, the most important is a gradual return to pitching when the patient is free of pain. In refractory cases, avoidance of throwing positions is advised for up to a year. (Norton et al., 2019) Immobilization and surgical fixation are considered in refractory cases and avulsion fractures. (Haws et al., 2018)

Stress Fractures

Stress fractures are common among runners and jumpers. Insufficient caloric intake and low vitamin D levels may predispose people to bony stress reactions. (Sonneville et al., 2012) They are caused by the mechanical overload of a cortical bone, with half of them occurring at the metaphyseal-diaphyseal part of the proximal tibia. (Valovich McLeod et al., 2011) Furthermore, the anatomic locations of stress fractures are associated with specific types of sports. (Fredricson, Jennings, Beaulieu, & Matheson, 2006) Runners usually suffer from stress fractures of the navicular bone, tibia, fibula, and metatarsal bones, while

metatarsal bones may also be injured in dancers. (Fredericson et al., 2006) The ulnar olecranon is the most common location of stress fractures in baseball players, while rib fractures are common among rowers. (Warden, Gutschlag, Wajswelner, & Crossley, 2002; Zaremski, Zeppieri, & Tripp, 2019) Stress fractures are often diagnosed late since the pain is vague and non-specific in location. The most common early radiographic evidence is periosteal apposition, which develops after three weeks of bone condensation at the fracture site. (Shanmugam & Maffulli, 2008) An MRI is usually performed to exclude an infection or tumor that could weaken the bone and cause a pathological fracture. (Shanmugam & Maffulli, 2008) Treatment consists of cast immobilization and avoiding weight bearing. If athletic triad or relative energy deficiency syndrome (RED-S) is known, the bone mineral density should be evaluated with a DEXA scan to exclude low bone mineral density. (Sweeney et al., 2020)

Spine

Spondylolysis and Pedicle Stress Fracture

Overuse syndromes in the lumbar spine are the second most common after overuse syndromes in the lower extremities. It is expected that 10 to 15 % of young athletes will experience lower back pain at some point throughout their sports career. However, the incidence among football players and gymnasts can be as high as 27 and 50 to 87 %, respectively. (De Luigi, 2014) Among those, weight lifters and dancers are known to be affected the most. (Congeni, McCulloch, & Swanson, 1997) Extreme movement of the lumbar spine, especially hyperextension and axial rotations, puts extensive stress on the posterior structures of the lumbar neural arch, resulting in a stress fracture of the pars interarticularis or spondylolysis, which may progress to a complete fracture and a slipped vertebrae or spondylolisthesis. A unilateral pedicle stress fracture often develops, which displays symptoms similar to spondylolysis. They include pain in the lower spine, exacerbated by hyperextension, and a positive Micheli's test. Although an X-ray may reveal the diagnosis, an MRI is performed to assess the compression of neural structures. Treatment consists of relative rest and avoiding strenuous activity for 4 to 6 weeks. (Herman, Pizzutillo, & Cavalier, 2003) Surgical management is suitable in the case of progression with signs of instability and spinal stenosis. (Wong, Lalam, Cassar-Pullicino, Tyrrell, & Singh, 2020)

PREVENTION

Many overuse injuries are avoidable; thus, prevention is critical. In recent years, the “Recommendations for the Prevention of Physical Activity-Related Injuries in Adolescents” were published. These recommendations were developed to provide guidance on how to prevent injuries related to physical activity among adolescents. (Mari & Jari, n.d.) The reader is invited to visit the link provided in the reference section.

Fatigue and decreased performance, in terms of both quality and quantity, are early signs of overuse injury. Early sport specialization, extensive year-round training to the exclusion of other sports (Myer et al., 2015), and a heavy training load are all connected to overuse injuries. (Sweeney et al., 2020) A young athlete’s appropriate training load and rest to improve adaptation without increasing injury risk is most likely determined by a variety of factors, including physical maturity, fitness level, biomechanics, sport environment, and other things. (Brenner & Watson, 2024) For young and middle school athletes, a basic rule of thumb is to limit the hours spent in organized sports each week to fewer than the youth’s age in years. (Jayanthi, LaBella, Fischer, Pasulka, & Dugas, 2015) In several sports, the injury risk is less than 10% when the acute/chronic load ratio (e.g., the previous week’s training load or the 4-week rolling average of the load) is between 0.8 and 1.3. (Soligard et al., 2016)

In general, most recommendations made by sports medicine organizations and based on existing research in clinical and community-based cohorts of young athletes oppose early sport specialization, meaning that one should only specialize in a single sport after the age of 12. (Jayanthi, Post, Laury, & Fabricant, 2019)

Nonetheless, in addition to physical stress, the intense training associated with youth sports specialization tends to have a detrimental effect on an athlete’s psychological well-being. It can lead to social isolation, altering an athlete’s identity. (LaPrade et al., 2016) Perfectionism and unrealistic expectations set by parents and coaches present excessive psychological stress. (Bergeron et al., 2015) If an athlete cannot cope with the load, maladaptive coping strategies, loss of motivation, mood disturbances, and even burnout can follow. (LaPrade et al., 2016) Youth athletes must be involved in preventive management. (Lau-nay, 2015) They should be adequately educated to listen to their own body and express the first signs of pain and discomfort in order to adjust their training routine, reduce the number of competitions, and start the proper rehabilitation before an overuse syndrome develops. Most sports organizations suggest that youth players take more than one month off from their sport in a year, pursue

fewer weekly training hours than their age, and have an established support system both in the sport and at home to reduce the psychological impacts of a professional sports career. (Jayanthi et al., 2019)

Although sports specialization has been associated with potentially harmful psychological health consequences, long-term impacts require more research. (Jayanthi et al., 2019)

CONCLUSION

Addressing the growing issue of overuse syndromes in young people requires a multi-faceted approach. This includes promoting sports diversification, educating athletes and parents about injury prevention, emphasizing the importance of rest and recovery, and fostering a balanced and healthy approach to physical activity.

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