DOI: https://doi.org/10.17816/PTORS633296

Review

Musculoskeletal injuries and pain in children involved in sports: A literature review

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ABSTRACT

BACKGROUND: In children, sports aims to obtain positive emotions and improve health and personal development. Sports injuries are associated with various risk factors, such as sex, age, previous injuries, and early specialization.

AIM: This study aimed to analyze published data on the epidemiology, etiology, pathogenesis, and diagnosis and treatment of musculoskeletal injuries and associated pain in children engaged in sports.

MATERIALS AND METHODS: The literature regarding the epidemiology, diagnosis, and treatment of pain in children involved in sports was explored. The literature search garnered 64 publications, including original articles, reviews, and normative documents.

RESULTS: For most athletes, pain commonly occurs during training and competition. Injuries are an inherent risk when playing sports. However, coaches and parents can minimize the risk of injury by ensuring that they choose the right sports activities, use appropriate equipment, follow the rules, use safe practice, and provide adequate supervision. The negative consequences of sports injuries must be balanced with the social, psychological, and health benefits of sports participation.

CONCLUSIONS: Treatment of injuries and analgesia must be implemented effectively to prevent pain from becoming chronic and reduce psychological burden on the young athletes.

Keywords: sport; children; pain; analgesia.

To cite this article

Kenis VM, Baindurashvili AG, Sapogovskiy AV, Melchenko EV, Kasev AN, Shpulev PS. Musculoskeletal injuries and pain in children involved in sports: A literature review. *Pediatric Traumatology, Orthopaedics and Reconstructive Surgery.* 2024;12(2):271–283. DOI: https://doi.org/10.17816/PTORS633296

Received: 07.06.2024 **Accepted:** 11.06.2024 **Published online:** 27.06.2024

УДК 616.7-001-009.7-053.2:796.071(048.8)
DOI: https://doi.org/10.17816/PTORS633296

Научный обзор

Травмы опорно-двигательного аппарата и болевой синдром у детей, занимающихся спортом (обзор литературы)

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АННОТАЦИЯ

Обоснование. В детском возрасте спорт нацелен на получение положительных эмоций, улучшение здоровья и гармоничное личностное развитие. Спортивные травмы ассоциированы с различными факторами риска, такими как пол, возраст, предыдущие травмы, ранняя специализация.

Цель — анализ опубликованных данных, посвященных эпидемиологии, этиологии, патогенезу, диагностике и лечению травм опорно-двигательного аппарата и связанного с ними болевого синдрома у детей, занимающихся спортом.

Материалы и методы. Изучена литература, посвященная проблеме эпидемиологии, диагностики и лечения боли у детей, занимающихся спортом, с последующим анализом основных положений и фактических данных. В результате поиска отобраны и проанализированы 64 публикации, включавшие оригинальные статьи, обзоры и нормативные документы.

Результаты. Для большинства спортсменов боль — обычное явление на тренировках и соревнованиях. Занятия спортом связаны с неотъемлемым риском травм. Тренеры и родители могут свести к минимуму риск травм, обеспечив правильный выбор спортивных занятий, использование соответствующего оборудования, соблюдение правил, создание безопасных условий для занятий и обеспечение надлежащего наблюдения. Важно сбалансировать негативные последствия спортивных травм с многочисленными социальными, психологическими и медицинскими преимуществами занятий спортом.

Заключение. Лечение повреждений и аналгезия должны быть неразрывно связаны, проводиться наиболее эффективным образом, чтобы избежать перехода боли в хроническую форму, а также дополнительной психологической нагрузки на юного спортсмена

Ключевые слова: спорт; дети; боль; аналгезия.

Как цитировать
Кенис В.М., Баиндурашвили А.Г., Сапоговский А.В., Мельченко Е.В., Касев А.Н., Шпулев П.С. Травмы опорно-двигательного аппарата и болевой синдром у детей, занимающихся спортом (обзор литературы) // Ортопедия, травматология и восстановительная хирургия детского возраста. 2024. Т. 12. № 2. С. 271–283. DOI: https://doi.org/10.17816/PTORS633296

Рукопись получена: 07.06.2024 **Рукопись одобрена:** 11.06.2024 **Опубликована online:** 27.06.2024

BACKGROUND

Physical activity is crucial for a child's overall well-being. A well-designed exercise program enhances physical, psychomotor, and intellectual capabilities [1]. Over the past two decades, participation in sports competitions has become an essential part of childhood in most countries. There has been a significant increase in the number of children participating in both team and individual sports. In childhood, sports are intended to provide positive emotions, improve health, and promote harmonious personal development [2]. However, this balance changes when the competitive element intervenes, leading to the undesirable but inevitable consequence of a significant increase in the number of sports injuries [3, 4].

Sports injuries are a significant concern for clinicians and researchers. Injuries in children and adolescents represent a major public health problem, accounting for 30–40% of all injuries [5, 6], with a wide range of negative consequences [7].

Various risk factors are associated with sports injuries, including gender, age, previous injuries, early specialization, etc. [8]. Studying and understanding these risk factors is essential for developing effective injury prevention strategies for children and adolescents [9, 10].

Any sport can lead to musculoskeletal injuries. However, most sports-related injuries in children and adolescents are relatively mild. Training programs and performance assessment standards should consider the biological age and physical and psychological maturity of the sports participants rather than their chronological age. In-depth knowledge of various training aspects, including duration, intensity, frequency, and recovery, is necessary to prevent serious musculoskeletal injuries in children's sports activities.

The work aimed to analyze published data on the epidemiology, etiology, pathogenesis, diagnostics, and treatment of musculoskeletal injuries and associated pain syndrome in pediatric patients involved in sports.

MATERIALS AND METHODS

To achieve this aim, the literature on the problem of epidemiology, diagnostics, and treatment of pain in pediatric patients involved in sports was studied, followed by an analysis of the main provisions and evidence. The search for publications was performed using the PubMed and Web of Science databases using the keywords "young athletes," "children," "sport," "trauma," "injury," and "pain," as well as the Russian scientific electronic libraries eLibrary.ru and CyberLeninka using the keywords "children," "sport," "trauma," "pain." As a result, of the search, 64 publications were selected and analyzed, including original articles, reviews, and normative documents. When selecting literature sources for subsequent analysis and synthesis of information, preference was given to publications in highly rated international journals and studies with a high level of evidence. Considering the diversity of the described data, the principle of a narrative review was chosen for summation and analysis, which consistently presents the main facts presented in the literature on this issue.

RESULTS AND DISCUSSION

Epidemiology of injuries and pain syndrome in pediatric patients involved in sports

Athletes often suffer from diseases and injuries, and pain is the main complaint, which is determined by the specifics of sports. This makes the objective assessment of epidemiological indicators of pain during sports methodologically difficult. Although pain management in elite athletes in general has received increased attention in recent decades, epidemiological data on the incidence and prevalence of pain, particularly in youth athletes, are limited.

Epidemiological analysis in sports traumatology aims to quantify the frequency of sports injuries based on circumstances and demographic and physiological factors. Attempts are being made to explain the causes of certain sports injuries and to develop prevention strategies [11].

The incidence of sports injuries varies according to specialization, age, gender, and skill level [12]. Accurate estimation of injury rates in youth sports is particularly challenging and varies widely across different pediatric populations, depending on the methodology used and the type and severity of injuries. Additionally, varying criteria for defining injuries complicate comparisons of results, and such data should be interpreted with caution. Consequently, the exact statistics and epidemiology of sports injuries in children are unknown, with data varying significantly depending on the nature of the studies.

The risk of injury is generally higher in young children due to their lack of awareness of sports-related risks, and parents are often unable to mitigate these risks using evidence-based prevention principles [13]. Daily physical activity decreases as children grow older [14], and their motivation to exercise diminishes during adolescence [15]. As adolescents become more independent, they experience less parental supervision during physical activities and frequently sustain injuries during team sports [16]. In a multicenter study, over a third of adolescents aged 15 and older reported at least one injury requiring medical attention during the previous year, with half of these injuries occurring while playing sports [17]. Peak rates of emergency department visits for sports injuries occur at ages 5–14 years and gradually decline with age.

Specifically, in the United States, of the 2.6 million annual medical visits for sports-related injuries, the highest incidence is among school-aged children (5–12 years), adolescents (13–18 years), and young adults (18–24 years) compared to other age groups, with 38% of high school students and 34% of middle school students seeking medical help for a sports injury at least once [18].

Most studies examining sports injuries among children and adolescents have revealed that boys are more prone to injuries due to their higher risk-taking behavior, lack of protective equipment, and socialization problems [19, 20].

Data on the incidence of injuries in boys and girls vary depending on sport specialization, with sports-related injuries in boys occurring approximately twice as often as in girls [21, 22]. Some studies report similar injury rates for boys and girls, but boys tend to suffer more severe injuries. In certain sports, such as horse riding, injuries in girls are several times more common (in particular, spinal injuries are seven times more common) than in boys [23]. Contact sports and sports involving jumping have the highest injury rates.

From both theoretical and practical perspectives, the influence of an athlete's level of achievement on the probability of injury is interesting. Previously, in a classic study involving one of the most respected experts on childhood sports injury, Nicola Maffouli, it was noted that high-level athletes had lower injury rates than the average among young athletes [24]. However, more recent studies have shown that in modern elite sports, the incidence of injuries and visits to doctors for help is quite high, so at the time of the study, 47.9% of young athletes reported an injury, and 9.1% reported an illness. The average injury rate was 8.6 injuries per 1,000 hours of sports activity [25]. In general, sports injuries increase with age, approaching the level of adults among older children.

Aspects of injuries and pathogenesis of pain during sports in pediatric patients

Despite the apparent association between injuries and pain, the biological mechanisms of injury and nociception are interrelated but not identical. Not all injuries necessarily cause pain, just as not all pain results from injury. Treatment of pain and treatment of injury are not always identical [26]. Additionally, treatment of injuries in itself does not always lead to pain relief. Therefore, it is necessary to emphasize the importance of pain management and the inadmissibility of chronic "oligoanalgesia" in children involved in sports.

Pain sensations in young athletes are affected by physiological growth and psychological development characteristics. The perception of pain is also influenced by factors such as psychological mood, family situation, relationships with a coach, peers, and other social reasons [27].

To understand the specifics of childhood sports injuries, it is important to get an idea of the characteristics of the child's musculoskeletal system. Tendons and ligaments in children are relatively stronger and much more elastic than the epiphyseal plate. Therefore, in the event of severe trauma, the epiphyseal plate, being weaker than the ligaments, is susceptible to damage. Accordingly, growth plate injury in children is more common than ligament injury [28, 29].

Generally, bones and muscles in children are characterized by increased elasticity and repair capacity, although specific indicators regarding these differences are highly uncertain [30]. During peak linear growth, adolescents are susceptible to injury due to imbalances in strength and flexibility and changes in bone biomechanical properties. Physiological stress is beneficial for the skeleton; however, excessive stress can lead to serious injury. Studies comparing the incidence of injury among different groups of young athletes have established that moderate-intensity training can stimulate bone growth, while high-intensity training can inhibit it. Sports injuries can damage bones and soft tissues, potentially leading to irreversible and progressive consequences [31].

Sprains, bruises, and fractures are the most common types of injuries in young athletes, with the anatomical location of injuries correlating with the type of sport [3]. Younger child athletes more often sustain upper extremity injuries, while adolescents are more prone to lower extremity injuries, which are more likely to require surgical intervention [32]. Adolescent female athletes tend to suffer from overexertion injuries (enthesitis, apophysitis, stress fractures) more often, while male athletes are more often affected by direct traumatic injuries [33].

Compared to adults, adolescent athletes have higher levels of pain, greater anxiety, and catastrophic thoughts [34].

The severity of sports injuries can be determined based on the time required to return to physical activity and/or sport. A period of one to three weeks corresponds to mild to moderate injury [35]. Few severe injuries are associated with a long time to return to activity, often due to persistent pain syndrome [36].

Psychological problems of pain management in young athletes

Athletes have a unique attitude toward pain due to the specific nature of their activities. Sports injuries or chronic diseases, along with the associated pain, often occur as natural consequences of sports activities. However, an athlete's psychological response to pain is influenced by his or

her perception of the injury, the short- and long-term impact on athletic results, non-sport activities, and treatment expectations [37].

Pain can lead to emotional distress, including irritability, anger, and anxiety. If psychological problems are not recognized and treated, they can interfere with effective pain management.

Stress during sports is a risk factor for sports injuries and pain syndrome. Depression and anxiety are risk factors for poor response to treatment in youth athletes with acute or chronic pain. Fear of pain or re-injury can lead to avoidance of physical activity, resulting in increased pain and decreased functioning in many spheres of life, including school, sports, and social activities. Disturbed sleep also affects the athlete's pain and recovery [38].

Parental responses to a young athlete's pain may influence pain perception and other pain-related disorders. Peer relationships are crucial for adolescents, and continuing their habitual activities and social bonding is one of the best ways to accelerate recovery from injury. Relationships with coaches and team members can positively and negatively affect pain experience and treatment response [39]. Chronic pain is a very complex phenomenon and difficult to treat; if a young athlete's pain becomes chronic, it is best treated in a multidisciplinary pediatric pain clinic. This problem falls outside the scope of this study and requires a separate discussion.

Risk factors and prevention of injuries and pain in young athletes

Although standard physical education programs include injury prevention measures, injuries still occur in physical education classes. Moreover, some authors have reported that sports-related injuries are more common than injuries related to leisure-time physical activity [40].

Several well-known risk factors contribute to sports-related musculoskeletal injuries in children. During growth spurts, the elasticity of bone tissue decreases due to the relative lengthening of the bones. This predisposes to injury if appropriate stretching exercises are not performed before participating in sports. While studies in adults have shown that stretching before exercise does not reduce the incidence of injury, it has not been determined whether this finding applies to children. Exercising in inappropriate conditions or using inappropriate shoes can also lead to injury. A good practice is to cross-train and gradually change the training schedule, as well as the use of specially designed warm-up and neuromuscular training programs [41].

Preventing sports injuries in children is important for reducing both short- and long-term social and economic consequences. Most preventive measures outlined in the literature are based on descriptive studies rather than risk factors confirmed as reliable predictors in correlational or experimental studies. The general risks and trends leading to childhood injuries are assessed quite broadly. Research evidence indicates an association between specific risk factors and injuries, suggesting that methods for their prevention may be developed based on these associations [42].

Sports-specific studies show similar findings regarding safety, adequate supervision, and the importance of warm-ups and protective equipment [43].

The importance of pre-screening lies in limiting participation in certain sporting activities for children in the most vulnerable categories. For instance, balance assessment can serve as a predictor of future ankle injuries. Prevention relies on determining the necessary physical fitness, joint mobility, and general health, and these parameters should be assessed accordingly. Pre-season training has been shown to reduce injury rates early in the season [44]. The advisability of systematic sports activities for children with certain disorders of the musculoskeletal system, which may not allow the young athlete to achieve high results or contribute to injuries and the progression of diseases, is particularly acute. This issue warrants dedicated research and separate discussion.

Psychological aspects of readiness for sports, including the child's attitude toward possible pain, the participation of coaches and parents in overcoming the consequences of injury and "expectation" of pain, and "catastrophic thinking," play a crucial role in the adaptation of a young athlete to the conditions of training and competition, as well as prevention of repeated injuries associated with the child's psychological unpreparedness to continue in sports [45].

Diagnostics and assessment of pain intensity in young athletes

Pain in athletes is a common complaint, but its diagnostics can sometimes be quite complicated. Pain is a complex and dynamic interaction between biological, psychological, social, and environmental factors unique to each individual, which modify and reinforce each other. These features should be considered when making a comprehensive diagnosis, including anatomical and psychosocial factors. As a result, of a comprehensive diagnostic process, an array of information is formed that determines treatment approaches and duration.

Injuries can occur acutely, typically involving macroscopic tissue damage such as a fracture or sprain, or occur gradually as a result of repeated microtraumatic events, such as stress fractures, osteochondritis dissecans, apophysitis, and tendinopathy. In acute trauma, the clinical presentation

manifests itself immediately after the injury, and the history and mechanism of injury are typically straightforward. Clinical examination (examination, palpation) enables to determine the probable diagnoses and further examinations. Microtrauma or overexertion injuries, however, manifest less noticeably and usually occur during physical activity. In younger child athletes, such injuries may result in reduced performance or limping. Accurate identification of the injured anatomical area can be challenging. A thorough history and examination are of fundamental importance. The type of sport the child practices may provide additional clues to a probable diagnosis.

Certain sports are associated with specific types of injuries. For example, spiral fractures of the tibia most often occur in children when skiing [46], and ankle joint injuries occur most often when playing basketball [47].

The diagnostic algorithm for acute pain in young athletes may vary depending on the type and severity of the injury, the child's age, and the level of care (primary, specialized, etc.), but the main stages of diagnostics can be identified [48].

1. Taking anamnesis:
   – mechanism of injury or medical history;
   – previous injuries or illnesses in history;
   – associated symptoms (swelling, sensory disturbances, weakness, fever, shortness of breath);
   – limitations in daily activities or sports due to pain;
   – features of training and physical conditioning (increasing duration, changing the nature of training);
   – general health (comorbidities, medications, nutritional supplements, substance use, diet, sleep schedule);
   – physical and emotional development.
2. Characteristics of pain syndrome:
   – onset (at the time of injury or later);
   – localization (local, diffuse);
   – duration;
   – quantitative assessment;
   – pain intensity;
   – the impact of pain on activity (sports, school, sleep, mood);
   – characteristics (stabbing, dull, radiating, burning);
   – modifying factors (movement, certain loads);
   – daily intensity (pronouncement in the morning or evening);
   – effect of previous treatment (reduction of loads, fixation, medications).
3. Psychological factors:
   – social stress;
   – home and school environment;
   – stress associated with competitions, relationships with the coach and teammates;
   – probable signs of depression and anxiety.
4. Physical examination:
   – general assessment of the area of soreness (range of motion, muscle strength);
   – external signs (changes in skin color, sensitivity disorders, temperature changes, determination of the boundaries of the soreness area);
   – feasibility and possibility of additional consultations and examinations.

Treatment of pain syndrome during sports in children and adolescents

Treatment of injuries and analgesia must be inextricably linked and performed in the most effective manner to avoid pain becoming chronic, as well as an additional psychological burden on the young athlete [49].

Sprains, dislocations, fractures, and cerebral concussions are the most typical acute sports injuries accompanied by pain. Children experience the most severe pain either at the time of injury or during the first 48 hours after injury [50]. Immobilization for acute musculoskeletal injuries reduces pain intensity in children, while cooling the area of injury may increase the pain intensity [51].

Drug therapy

Specific algorithms for drug treatment of acute pain due to sports injuries in pediatric patients have not been developed. It is essential to consider the strict specificity of prescribing medications in children, as well as the no less strict anti-doping orientation in modern sports, including junior sports. Not all drugs comply with the anti-doping policies of regulatory authorities, as outlined in relevant documents [52]. Paracetamol and ibuprofen are drugs that are approved for use in junior athletes (under 18 years of age). A fixed combination of ibuprofen and paracetamol in one drug in an anesthesia regimen in outpatient practice can reduce the risks of dosing violations and provide the necessary therapeutic effect when prescribed hourly. In Russia, this combination is registered in the form of dispersible tablets.

The same approaches used for general musculoskeletal injuries are applied to sports injuries in children. The most significant and least developed question remains the choice of pain management options within the context of ongoing sports activities. Children with sports injuries typically initially contact primary care providers or emergency physicians to treat acute pain. Among oral pain medications whose effectiveness has been studied in young athletes, the world medical literature mentions analgesics such as ibuprofen, naproxen, acetaminophen, and codeine.

Researchers have attempted to determine the optimal drug pain management in pediatric patients. A comparative

study found no statistical difference in pain relief between acetaminophen and naproxen in pediatric patients with soft tissue injuries of the ankle [53]. However, ibuprofen provided faster and greater pain relief than acetaminophen or codeine in pediatric patients with musculoskeletal injuries [54]. Ibuprofen was equally effective compared with a combination of acetaminophen and codeine in children with extremity injuries for pain relief [55]. It was more effective in restoring mobility, with fewer cases of nausea and vomiting [56]. Adding codeine to ibuprofen did not improve the analgesic effect in pediatric patients with musculoskeletal injuries compared with ibuprofen and placebo [57].

Several studies have shown that opioids are not superior to ibuprofen in terms of pain relief efficiency or side effect profile and, therefore, should not be used in the treatment of acute musculoskeletal injuries. Some practitioners prefer not to prescribe ibuprofen for acute injuries due to concerns about adverse effects on bone consolidation [58]. However, a retrospective study of pediatric patients with extremity fractures revealed no association between ibuprofen use and nonunion, delayed consolidation, or secondary fracture displacement [59].

Athletes who develop subacute or chronic pain are at greater risk for comorbid mental conditions. There is a psychological response to pain, with many psychosocial factors complicating diagnostics and response to treatment. Young athletes experiencing pain and lack effective coping strategies may self-medicate. The ongoing opioid epidemic in the United States represents a heavy burden on the healthcare system. The annual economic and non-economic costs of opioid use and fatal opioid overdose are estimated at $1 trillion. A review of the prevalence, frequency of use, necessity, and effectiveness of opioid analgesia among youth athletes identified the current indications for opioid and non-opioid analgesics for acute injury, postoperative management, cerebral concussion, and chronic pain in youth athletes. Patients in this category constitute a high-risk group and often require painkillers for injury-related pain. Participation in sports in high school is associated with an increased risk of opioid use. On average, 28% to 46% of high school athletes have used opioids in their lifetime. Participation in school sports increases the probability of opioid abuse in adolescents by 30%. The authors conclude that opioid use among youth athletes is common and is associated with both short- and long-term risks of abuse and dependence [60].

In a study of 108 pediatric patients aged 6 months to 18 years, the combination of paracetamol and ibuprofen was more effective than either drug alone for pain relief [61].

Study results in adult patients suggest that ibuprofen and its combination with paracetamol have similar or better analgesic effects than morphine in patients with closed limb fractures. Combination therapy showed the most consistent pain reduction [62]. The study authors emphasize the potential of non-opioid analgesics in the treatment of fracture pain and the importance of initiating the use of these drugs as first-line analgesics in patients with fractures. These findings can be extrapolated to varying degrees of injuries during sports in children.

CONCLUSION

For most athletes, pain is a common occurrence during training and competition. At the same time, considering the specifics of sports activities, treating pain in athletes requires a comprehensive, individual, and patient-oriented approach. Both adult athletes and their coaches are, in most cases, able to assess the severity of pain and the risks of continuing sports activities or the advisability of visiting a doctor. The attitude toward pain in children, in general, differs from that of adults, as while learning about the world, a child inevitably encounters situations in which pain and the negative emotions accompanying it are almost inevitable. The first active movements in space (crawling, standing up, walking, running) are accompanied by falls, blows, and failures. The child's parents and the athlete's coach, in most cases, based on their own experience, can distinguish a momentary negative emotion from the pain that arises from injuries that require appropriate treatment. This borderline is quite thin in both cases. The motivation of a young athlete, on the one hand, and his physical and psychological unpreparedness to perceive difficulties, on the other hand, close the paradigm within which the doctor, coach, and parents must come to a common understanding while putting the interests of the child at the forefront. This trinity of factors surrounding the child very clearly reflects the biopsychosocial approach adopted in modern pain physiology, when biological (age-related physiology, features of the sports injury itself), psychological (peculiarities of interpretation of pain by children, the desire to achieve results), and social (responsibility to the coach, parents, team) factors leave an inevitable imprint on the diagnostics of pain syndrome and treatment of the child and determine the relevance of generalizing information on this problem [63].

In modern teaching about pain, the concept of "oligoanalgesia," which literally means "insufficient treatment of pain," is more often applied. The term "oligoanalgesia" was proposed by Wilson and Pendleton in 1989 [64]. Traditionally, it has been identified as the insufficient use of analgesics in a given clinical situation in patients in emergency medicine and intensive care departments. Taking into account the information presented above regarding pain management in young athletes, it appears that

there is an incomplete correspondence between the pain sensations associated with a sports injury in children and the limited practice of pain management in such situations. Whether the concept of oligoanalgesia can be used concerning this situation is a matter of interpretation of the terms. However, taking into account the incidence of injuries in children involved in sports, it is highly probable to assume a state of chronic oligoanalgesia in patients in this category. Involvement in sports carries an inherent risk of injury. However, coaches and parents can minimize the risk of injury by ensuring the choice of proper sports activities, use of the appropriate equipment, following the rules, creating a safe practice environment, and providing adequate supervision. It is essential to balance the negative consequences of sports injuries with the many social, psychological, and health benefits of sports participation.

ADDITIONAL INFORMATION

Funding source. The study was performed within the research topic "Monitoring the state of the musculoskeletal system in children involved in sports and not involved in sports, based on a comprehensive assessment of the level of motor activity, clinical imaging, biomechanical parameters, as well as biomarkers of the condition of bone and muscle tissue" (registration number 1023030700030-9-3.2.10).

Competing interests. The authors declare that they have no competing interests.

Author contributions. All authors made significant contributions to the study and preparation of the article, and read and approved the final version before publication.

The largest contribution was distributed as follows: *V.M. Kenis* created the concept development, performed the literature search and analysis, preparation of the article text; *A.G. Baindurashvili, A.V. Sapogovskiy, E.V. Melchenko, A.N. Kasev, P.S. Shpulev* analyzed the literature analysis and edited the article text.

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