PROBLEMS AND PROSPECTS OF EARLY DIAGNOSIS OF ANOMALIES IN THE DEVELOPMENT OF THE BONE SYSTEM IN CHILDREN ENGAGED IN SPORTS

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Abstract. *The article presents an analysis of modern approaches to early diagnostics of disorders of the skeletal system development in children and adolescents, especially those involved in sports, taking into account the world, domestic and regional (Uzbekistan) experience. Materials and methods - a systematic review of foreign, domestic and Uzbek literature published over the past 15 years was conducted, with an emphasis on clinical, instrumental, laboratory and digital diagnostic methods. Sources from the PubMed , Scopus , eLibrary , Google databases were used Scholar , as well as national medical journals. Results — modern achievements in the field of diagnostics of early osteogenesis disorders, osteopenia and other bone remodeling disorders in child athletes are summarized. Differences in the level of implementation of modern diagnostic methods in different countries, as well as systemic and methodological gaps in regional practice are revealed. Conclusions — it is necessary to integrate a multidisciplinary approach into the system of dispensary observation and prevention of disorders of the skeletal system development in children. It is proposed to develop uniform diagnostic algorithms and screening programs for child athletes taking into account individual risk and training loads.*

Key words: *Child athletes; diagnostics; skeletal system; osteopenia ; sports medicine; pediatric traumatology; early manifestations; screening; medical examination.*

Introduction. The modern children's and youth sports movement is becoming increasingly popular in many countries around the world, including the Republic of Uzbekistan. However, along with the unconditional benefit of systematic physical activity, the number of reports of cases in which children actively involved in sports are diagnosed with various anomalies in the development of the musculoskeletal system, often detected at late stages, is increasing. Such disorders are often disguised as adaptive changes in response to physical activity, which complicates their timely detection and correction.

The period of active growth of the child's body is characterized by high sensitivity of the musculoskeletal system to loads, especially if they exceed physiological limits. Unrecognized anomalies in the development of the skeletal system in combination with intensive training can lead to the formation of persistent deformations, chronic pain syndromes and premature end of a sports career, as well as to a decrease in the overall quality of life.

Despite the existence of separate diagnostic protocols and screening programs, there is currently no unified approach to the early detection of predisposition to pathologies of the skeletal system development in young athletes. This is especially relevant for developing countries, where access to high-tech diagnostic methods is limited, and preventive work in sports schools requires a systematic approach.

In connection with the above, it seems relevant to conduct a general analysis of scientific data on the early diagnosis of disorders of the development of the skeletal system in children involved in sports, taking into account domestic and foreign experience, as well as the practice implemented in Uzbekistan.

The purpose of this article is to review the literature and existing approaches to early detection of skeletal abnormalities in young athletes, identify the main problems and outline promising directions in this area.

Relevance. (review of foreign literature).

According to Caine et al ., 2018 , up to 20% of young athletes in adolescence show signs of bone growth abnormalities, including osteochondropathy , apophysitis , and postural deformities, including scoliosis. Maffulli et al ., 2020 emphasize the role of the early pubertal growth spurt as a critical period during which the risk of developing skeletal deformities increases several-fold. DiFiori et al ., 2017 emphasize that too early specialization in one sport is associated with a higher risk of microtrauma, delayed epiphyseal fusion, and the formation of chronic overload in growth zones.

Methods of early diagnostics in foreign practice . Loud et al ., 2019 describe the use of routine screening with digital posturography and functional biomechanics in the United States and Canada as a mandatory element of the preparation of young athletes. Bennell et al ., 2021 report on the results of using ultrasound monitoring of epiphyseal growth , especially in children with a family history of orthopedic pathologies. In a number of EU countries, multidisciplinary approaches (orthopedist + pediatrician + sports trainer) are being introduced, which allows for the early detection of pathological adaptations of the skeletal system (Tedesco et al ., 2022).

Modern research in the fields of pediatric orthopedics, sports medicine and pediatric bioengineering demonstrates significant progress in the development of highly sensitive and non-invasive methods for detecting early changes in bone tissue. So u ultrasound osteodensitometry (Quantitative Ultrasound (QUS) has become popular as a safe and affordable way to assess bone mineral density in children. In the work of Szabo et al . (2019) QUS has been shown to detect decreased mineralization before radiographic evidence of osteopenia appears . Proton density MRI has been used to detect hidden inflammatory or destructive processes in growth plates in adolescent athletes (Roth et al ., 2020). Functional radiography with 3D

reconstruction used in Yoshida's research et al . (2021) to assess the spatial deformation of the spine in latent scoliosis at an early stage.

Several studies (Bianchi & Baim , 2018) point to the value of assessing bone remodeling markers (e.g. osteocalcin , β- CrossLaps , P1NP) for diagnosing metabolic disorders in bone in children with high physical activity. Wey et al . (2022) conducted a study in which children with early signs of osteopenia demonstrated abnormal levels of bone biomarkers 6–12 months before radiographic changes.

High-resolution technologies peripheral quantitative computed tomography (HR- pQCT) allow detailed assessment of bone microarchitecture. Macdonald et al . (2020) used this method to study microdamage in young athletes, particularly in the knee and hip area. Mayhew et al . (2021) showed that underweight adolescents who were also highly physically active had significant reductions in trabecular density parameters when using micro-CT.

Hollister et al . (2021) describe the use of machine learning (ML) algorithms to analyze postural photographs and predict the risk of developing spinal deformities. In the study, Nguyen et al . (2023) tested a mobile screening module based on neural network assessment of posture and body weight distribution, with a sensitivity of over 90% in detecting early scoliosis.

Zhao et al . (2022) highlight the potential of molecular genetic methods, such as the identification of polymorphisms of the VDR, COL1A1 and COL2A1 genes associated with the risk of dysplasia and low bone mass in children. Such studies are actively used in sports medicine to assess the predisposition to musculoskeletal injuries.

Material and methods. (domestic (Russian and post-Soviet) studies).

G.A. Malakhov (2016) indicates that the most common anomalies are juvenile kyphosis, scoliosis, joint dysplasia, and lower limb axis disorders. S.N. Agapova et al . (2019) conducted a clinical and radiological study of 150 adolescents involved in wrestling and gymnastics and found signs of impaired ossification of the pelvis and spine in 32%.

I.I. Kasatkin (2020) emphasizes the importance of comprehensive diagnostics, including gait biomechanics, orthopedic examination, and neurophysiological testing (in particular, electromyography). A.A. Sidorov (2021) proposed a method for assessing spinal stability using digital stabilometry , demonstrating its high sensitivity to early disorders.

M.A. Piskunov et al . (2019) noted the importance of using digital radiography with subsequent morphometric assessment for the early detection of hip dysplasia and spinal curvature in primary school children. S.V. Bessarabov (2020) substantiated the use of X-ray structural analysis of the spine and joints in children involved in artistic gymnastics as a method that allows for the early detection of areas of overload and compensatory restructuring of bone tissue. The studies of A.N. Astashkin (2021) report the effectiveness of MRI with diffusion-weighted modes for assessing the structure of cartilage and bone tissue in suspected osteochondropathy in adolescents.

Yu. S. Litvinova et al . (2022) studied the parameters of calcium, vitamin D, and osteotropic hormones (PTH, calcitonin) metabolism in adolescents actively involved in martial arts. Signs of subclinical vitamin D deficiency and calcium metabolism disorders were detected in 27% of the subjects. E. P. Khlestov (2018) proposed using osteocalcin and alkaline phosphatase as markers for early diagnosis of bone formation disorders in children with asymmetric loads (e.g., in tennis, fencing, wrestling).

In the works of I.V. Sokolovskaya et al . (2020) , the effectiveness of digital posturography and video analysis of movements in assessing the symmetry of posture, distribution of load on the feet and dynamic balance in adolescent athletes is noted . A.A. Nikolaev (2019) introduced the digital stabilometry method into the medical examination of young football players, which made it possible to identify the initial signs of muscle tone disorders and spinal stability.

S.N. Baranov et al . (2021) demonstrated the capabilities of surface electromyography (EMG) as a method for early diagnosis of hidden imbalances between muscle groups of the trunk and back, predisposing to the formation of

scoliotic deformities. I.A. Nosov (2022) used electroneuromyography (ENMG) in complex diagnostics of children with complaints of rapid back fatigue. In 40% of cases, a delay in impulse conduction in the paravertebral muscles was detected in the absence of anatomical changes.

T.I. Grushina (2019) proposed an algorithm for screening children at risk of bone dysplasia based on comprehensive schools and sports sections. The criteria were: poor posture, growth retardation, delayed biological age, and complaints of back pain. D.R. Usmanov (2023, Republic of Uzbekistan) implemented a mobile diagnostic complex for field examinations of athletes , including a digital questionnaire, visual analysis of posture and express assessment of motor patterns. The method has proven effective in rural areas.

Regional features and results of observations (and research conducted in the Republic of Uzbekistan).

According to Zh.A. Tashpulatov et al . (2021) , 18% of students in Tashkent sports schools who underwent a preventive examination were found to have signs of grade I–II kyphoscoliosis that were not detected during the initial examination. K.I. Dzhalalov (2022) in a study involving 90 children aged 10–14 years found that among frequently training stretching athletes (track and field), spinal mineralization was impaired at early stages, which was confirmed by densitometry. S.T. Ergashev et al . (2023) emphasize that in rural areas, the detection rate of disorders is significantly lower, which is due to insufficient qualifications of specialists and lack of equipment.

Khuzhanazarov I.E. et al . (2020) - "Clinic, diagnostics and treatment of fractures of the proximal radius in children and adolescents" (Eurasian Bulletin of Pediatrics, No. 3 (6), 42-45) - in a study of 147 patients with fractures of the proximal radius, the authors carried out X-ray diagnostics and showed that with timely recognition of injury and tactically correct treatment, the anatomy and functions of the elbow joint are completely restored tashpmi.uz . Bayimbetov G. and Khozhan I. (2021) - " New approaches to pediatric treatment of post-traumatic elbow contracts » (Genij Ortopedii 27(5):578–583) – 102 children with post-traumatic elbow

contractures were studied. All patients underwent standard radiography, ultrasound, and MSCT with 3D reconstruction; new methods of joint mobilization were developed. According to the results, all patients noted good outcomes, and the authors note that MSCT with 3D analysis of bone structures is the “gold standard” in the diagnosis of elbow contractures researchgate.net researchgate.net . Study (2022) « Bone mineral density and other risk factors in children and adolescents with low energy fractures of long bones » (Journal «Pain, Joints, Spine», 12(4):176–181) – dual-energy X-ray absorptiometry (DXA) and analysis of biochemical markers were performed in 230 children (6–17 years) with bone fractures at the Traumatology Clinic of Uzbekistan. Decreased bone mineral density (BMD) in the lumbar spine was found in 86 children (37%); only 19.3% of girls and 9.2% of boys had normal vitamin D levels, while most had low calcium levels and increased alkaline phosphatase activity. A direct correlation was established between low BMD and vitamin D deficiency ($p<0.05$) pjs.zaslavsky.com.ua pjs.zaslavsky.com.ua . These data indicate that densitometry (DXA) and imaging (X-ray, CT) in combination with biochemistry can detect hidden bone structure disorders and osteopenia risks in children. Research Institute of Traumatology and Orthopedics (Tashkent) - densitometry and ultrasound diagnostics rooms have been created in the radiation diagnostics department of the Research Institute of Traumatology and Orthopedics. Dual-energy X-ray absorptiometry and sonodensitometry are performed here to assess bone density, as well as MSCT for complex cases uzniito.uz uzniito.uz . A school of specialists in X-ray diagnostics of the musculoskeletal system is being formed.

Rasulova N.A., Sharipov R.Kh. (2023) - "Justification of the need to determine 25 (OH) D3 in children to assess the quality of rickets prevention" (journal "Problems of Biology and Medicine" No. 2 (143), 2023) - the authors analyzed the effectiveness of rickets prevention in infants in Uzbekistan. It was found that despite the southern climate, bones suffer from vitamin D deficiency: rickets occurs in 27% of children in the first year of life. Correct administration of vitamin D in prophylactic doses can reduce the severity of rickets and improve the development

of babies sammu.uz . The authors insist on regular monitoring of 25 (OH) D3 in the blood of children as an indicator of the quality of prevention. Rasulova N.A., Khodjaeva N.N. (2023) – "The influence of 25(OH)D on the causes of rickets development in children" (special issue of Uzbek Medical Journal , SI-1) – a population-based study revealed that 28.9% of the examined infants had signs of rickets. Among the risk factors on the part of the child, the key ones were a low level of 25(OH)D3 in the serum (78.3% of cases) and the absence of vitamin D prophylaxis in the first year of life (68.9% of cases) tadqiqot.uz . Frequent acute respiratory viral infections and a lack of walks were also noted. On the part of the mother, the factors were refusal of vitamin D during pregnancy (85.2% of women), iron deficiency anemia (62.0%), etc. tadqiqot.uz . This emphasizes the importance of monitoring biochemical parameters (vitamin D, calcium, phosphorus, alkaline phosphatase) in high-risk groups. N.A. Rasulova et al . (2020) - a similar study showed that 25(OH)D deficiency is much more common than clinically expressed rickets and can be one of the early markers of phosphorus-calcium metabolism disorders pjs.zaslavsky.com.ua pjs.zaslavsky.com.ua . Thus, domestic studies emphasize the role of laboratory screening of 25(OH)D3, calcium and alkaline phosphatase levels for the early detection of bone metabolism disorders in children.

The Research Institute of Traumatology and Orthopedics has introduced methods of electro- neuromyography (ENMG) and computer podometry in examining patients with musculoskeletal pathologies uzniito.uz . ENMG of the lower extremities allows assessing neuromuscular conductivity and identifying neuromuscular disorders that affect posture and skeletal development. Computer podometry (baropodometry) is used to analyze the load on the feet and balance with various deformations. Such methods complement classical X-ray studies, allowing a comprehensive assessment of the somatic, muscular and nervous aspects of musculoskeletal diseases.

The growing role of digital technologies has been noted in the studies of traumatologists in Uzbekistan. For example, Bayimbetov and Khodzhanov (2021) used computed tomography with multispiral reconstruction and three-dimensional

analysis to diagnose elbow contractures researchgate.net researchgate.net . This made it possible to visualize bone impingements in detail and plan interventions. The availability of MSCT and 3D modeling in the clinics of the Republic increases the information content of diagnostics. The X-ray diagnostics department of the Research Institute of Traumatology and Orthopedics uses "digital" X-ray machines and pneumatic detectors for instant imaging, as well as specialized computer programs for podometry and posture analysis uzniito.uz . Local digital patient registries and mobile applications for remote consultations are being developed (examples of such projects were discussed at congresses of traumatologists of Uzbekistan).

Scientists recommend implementing screening algorithms for early detection of the risk of bone growth disorders. In particular, Rasulova and Sharipov (2023) emphasize the need for regular screening of 25(OH)D3 levels in children in the first year of life as a measure to assess the quality of rickets prevention sammu.uz . Research results show that risk factor analysis (low vitamin D, anemia, nutritional deficiency, seasonality of birth) can help identify groups of children susceptible to "hidden" bone pathologies tadqiqot.uz . In the context of Uzbekistan, it is proposed to expand the medical examination of young children, including an orthopedic examination and targeted examination (ultrasound of the hip joints, X-ray of the hands/feet in questionable cases, biochemical screening of calcium/vitamin D) sammu.uz tadqiqot.uz . The priority task is to create uniform national guidelines for screening for osteopenia /rickets in children (e.g. mass measurement of 25(OH)D3 and height/weight, assessment of nutritional status according to WHO) and follow-up treatment of identified deficiencies.**Conclusion.** The developed method of preoperative planning with determination of the optimal point for installation of the optical trocar in laparoscopic operations on the organs of the retroperitoneal space is effective, technically simple and allows to improve intraoperative parameters and reduce the frequency of iatrogenic surgical complications, especially at the stage of mastering laparoscopic operations.

Thus, taking into account the above data, a conclusion should be made about the expediency of using laparoscopic decortication due to its high efficiency. This technique allows achieving successful clinical results in 95% of patients, and the risk of complications is reduced to a minimum (about 1.4%). Undoubtedly, it is important to take into account the presence of clear indications described in the work, as well as to correlate with absolute and relative contraindications.

Discussion. The conducted literature review demonstrates the high relevance of the topic of early diagnostics of disorders of the skeletal system development in children, especially in the context of sports. Despite the abundance of research, approaches to diagnostics remain fragmentary and are often limited to clinical examination and radiography, without a full assessment of metabolic and neurophysiological factors.

In foreign practice (USA, Europe, Japan), a multidisciplinary approach is widely implemented: along with visualization methods (MRI, DXA, MSCT with 3D reconstruction), laboratory biomarkers (P1NP, CTX, 25(OH)D), neurofunctional diagnostics (EMG, posturometry), as well as digital monitoring of motor activity are actively used. This allows not only to identify early bone changes, but also to track the dynamics under the influence of training, therapy or prevention.

In domestic and post-Soviet studies, the emphasis has shifted towards the orthopedic and radiological approach, although in recent years ultrasound and biochemical screening have been increasingly introduced. However, the lack of uniform clinical protocols, insufficient availability of high-tech diagnostic methods in regional clinics and the shortage of qualified specialists (including in pediatric sports medicine) hinder the widespread use of modern tools.

Of particular interest are studies conducted in the Republic of Uzbekistan, where in recent years work has intensified on the introduction of DXA densitometry, ultrasound bone assessment methods, neurophysiological tests and digital podometry . At the same time, despite the proven importance of measuring the level of 25(OH)D, calcium and phosphorus, the practice of routine biochemical screening in children remains limited. Screening for rickets and osteopenia is focal in nature

and is not included in mandatory monitoring protocols for children, including athletes.

Thus, a systemic transition to a multifactorial assessment of the skeletal system (visualization, laboratory, neurofunction , digital technologies) remains a task for the near future. It is especially important to form a unified diagnostic trajectory for child athletes, taking into account their increased loads and risks of hidden osteogenesis disorders.

Conclusion Early diagnostics of disorders of the skeletal system development in children, especially those actively involved in sports, is the most important direction of modern sports medicine, traumatology and pediatric neurology. Analysis of foreign, domestic and Uzbek literature demonstrates a growing interest in a comprehensive assessment of the state of bone tissue at the earliest stages, long before the clinical manifestations of pathologies.

Modern methods, from digital imaging and biochemical markers to functional neurophysiological studies, make it possible to identify subclinical forms of osteopenia , remodeling disorders , and musculoskeletal stress in child athletes. However, their widespread implementation is hampered by a number of factors: limited access to technology, insufficient training of personnel, and the absence of national clinical guidelines and early diagnostic algorithms.

The development of multidisciplinary approaches involving sports physicians, orthopedists, neurologists, endocrinologists, pediatricians and medical rehabilitation specialists should become a strategic priority in the prevention of bone deformities, reducing injuries and increasing athletic longevity among children and adolescents.

A promising direction is the integration of screening programs into the system of dispensary observation of young athletes, using accessible and evidence-based diagnostic methods. This will allow not only to promptly identify deviations, but also to form individual programs for the prevention and correction of ossification and bone growth disorders in children.

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