



Clinical and Instrumental Features of Vertebrogenic Pain Syndromes in Children with the Identification of Risk Factors and Ways of Optimization

Oblanova Dinara Sirojiddin qizi

Department of neurology, 1st year master's degree, resident of

Shomurodova D.S.

Neurology Department, doctor of medical sciences, associate professor

Abstract: This article analyzes the clinical manifestations and instrumental characteristics of vertebrogenic pain syndromes in the pediatric population with special emphasis on the identification of key risk factors and the development of optimization strategies for early diagnosis and management. Vertebrogenic pain in children is increasingly recognized due to postural disorders, excessive academic load, sedentary lifestyle, congenital spinal anomalies, and early degenerative changes. The study integrates clinical observation with radiological and functional diagnostic methods to determine typical symptom patterns and structural abnormalities. The results demonstrate that early recognition of vertebral dysfunction and targeted preventive interventions significantly reduce pain progression, recurrence rates, and long-term functional impairment. This study provides an in-depth evaluation of the symptomatic presentation and diagnostic patterns of spinal pain syndromes of vertebral origin in the pediatric population with a special focus on determinant conditions that accelerate their development and on strategies aimed at improving clinical outcomes. The investigation demonstrates that pain in the axial skeleton during childhood is predominantly linked to reversible biomechanical dysfunctions rather than fixed organic lesions, and that timely identification through combined clinical assessment and modern instrumental diagnostics allows effective prevention of long-term structural damage. The findings confirm that targeted correction of lifestyle-related factors and early rehabilitation significantly decrease symptom persistence, recurrence frequency, and functional limitations, thereby improving quality of life and reducing the likelihood of chronic musculoskeletal disorders in adulthood.

Key words: vertebrogenic pain, children, spine disorders, risk factors, posture, musculoskeletal pain, MRI, functional diagnostics, rehabilitation.

Introduction:

Vertebrogenic pain syndromes in children represent a growing medical and social problem associated with the early onset of musculoskeletal dysfunction, reduced physical activity, and long-term disability risks. Unlike adults, pediatric patients often present with atypical, poorly localized pain, rapid fatigue, and functional limitations that may be underestimated by caregivers and clinicians. The developing spine is highly sensitive to mechanical overload, postural imbalance, and metabolic disturbances, which predispose children to early disc deformation, segmental instability, and muscular imbalance. School-related factors such as prolonged sitting, improper furniture, excessive use of electronic devices, insufficient physical activity, and backpack overload significantly



contribute to spinal stress. Additionally, congenital anomalies, connective tissue dysplasia, trauma, and inflammatory conditions further increase susceptibility to vertebrogenic syndromes. Timely identification of characteristic clinical and instrumental signs is essential to prevent chronic pain formation, secondary musculoskeletal deformities, and psychological consequences. This study aims to evaluate the combined clinical and diagnostic features of vertebrogenic pain in children, identify the most significant risk factors, and propose evidence-based optimization strategies for early intervention. Pain originating from the spinal column during childhood and adolescence has become an increasingly relevant clinical issue due to rapid changes in lifestyle, reduced motor activity, and prolonged exposure to static loads. The pediatric spine is characterized by high plasticity and sensitivity to external influences, making it especially vulnerable to improper posture, uneven mechanical stress, and insufficient muscular support. In contrast to adult populations, spinal pain in children frequently manifests through nonspecific complaints such as fatigue, reduced endurance, headaches, and transient stiffness, which often delays diagnosis and contributes to progression. The absence of early intervention may result in persistent neuromuscular imbalance, abnormal spinal curvatures, and premature degenerative changes. Understanding the clinical manifestations in combination with objective instrumental indicators is essential for recognizing early stages of vertebrogenic disorders. At the same time, identification of modifiable and non-modifiable contributory conditions provides a foundation for constructing rational preventive and therapeutic programs aimed at long-term spinal health.

Research Methods and Approaches:

The study was conducted on a cohort of 120 children aged 7–16 years who presented with recurrent or persistent back and neck pain of vertebrogenic origin. A detailed medical history was obtained, including lifestyle habits, physical activity level, posture characteristics, school workload, and previous trauma. Clinical examination included assessment of posture, spinal mobility, muscle tone, palpation tenderness, neurological reflexes, and pain intensity using age-adapted visual analog scales. Instrumental diagnostics consisted of plain radiography, functional spinal tests, ultrasound assessment of paravertebral muscles, and magnetic resonance imaging in selected cases with suspected disc or neural involvement. Postural stability was evaluated using computer-based stabilometry. Statistical analysis was applied to determine correlations between clinical severity, instrumental findings, and risk factor exposure.

Results:

Clinical evaluation revealed that the most frequent complaints were cervical and lumbar pain, stiffness after prolonged sitting, episodic headaches, fatigue, and decreased physical endurance. Postural disorders, including scoliosis, kyphotic posture, and flat back syndrome, were identified in more than two-thirds of examined children. Palpation demonstrated persistent paravertebral muscle hypertonicity and localized trigger zones. Instrumental studies showed functional segmental instability, early signs of intervertebral disc dehydration, asymmetric load distribution, and decreased physiological spinal curvatures. MRI findings in advanced cases revealed protrusions, Schmorl's nodes, and minor nerve root compression. Stabilometric analysis confirmed significant impairment of postural control in patients with prolonged symptom duration. Risk factor analysis demonstrated strong associations between vertebrogenic pain and sedentary behavior, improper sitting posture, low physical activity, obesity, and backpack overload. Children exposed to multiple risk factors showed earlier symptom onset and higher pain intensity. The clinical assessment revealed that the majority of examined children experienced recurrent discomfort in the cervical and lumbar regions, which intensified during prolonged sitting or after physical exertion. Functional limitations were manifested as reduced flexibility, rapid onset of fatigue, and asymmetry in paravertebral muscle tension. Instrumental diagnostics demonstrated that most pathological findings were functional in nature and included altered spinal alignment, irregular distribution of axial load, and decreased stability of motion segments. In a smaller proportion of patients, imaging techniques detected early morphologic alterations such as disc contour irregularities, intra-vertebral herniations, and minor neural



compression. Postural stability analysis showed a marked reduction in balance control proportional to symptom duration. Statistical evaluation confirmed a significant association between pain severity and prolonged sedentary behavior, excessive screen exposure, inadequate physical conditioning, and improper school ergonomics. Children exposed to several adverse factors simultaneously exhibited earlier onset of symptoms and more pronounced functional impairment.

Discussion:

The findings confirm that vertebrogenic pain syndromes in children arise from a complex interaction of biomechanical, structural, and lifestyle-related factors. The dominance of functional disorders over irreversible structural changes emphasizes the importance of early detection. Persistent muscular imbalance, postural asymmetry, and altered load distribution represent the primary initiating mechanisms of pain. Instrumental diagnostics play a crucial role in differentiating functional instability from organic pathology and in determining the stage of spinal involvement. The strong influence of school-related and behavioral risk factors highlights the necessity of preventive strategies at the educational and family levels. Optimization of management should include early postural correction, therapeutic physical training, ergonomic adjustment of study environments, reduction of static loads, and rational use of digital devices. Multidisciplinary rehabilitation programs combining physiotherapy, manual therapy, kinesiotherapy, and psychological support demonstrate high effectiveness in restoring spinal function and preventing pain chronicity. The obtained data indicate that spinal pain syndromes in childhood predominantly arise as a consequence of disturbed biomechanical equilibrium rather than irreversible structural damage. Muscular imbalance and postural asymmetry appear to represent the initial pathogenic mechanisms that subsequently lead to overload of intervertebral structures and altered neuromuscular regulation. The predominance of functional disturbances underscores the importance of comprehensive clinical and instrumental evaluation at early stages, when corrective measures are most effective. The strong influence of environmental and behavioral components confirms that prevention should be oriented not only toward medical intervention but also toward modification of daily habits and educational conditions. Optimization of management requires an integrated approach combining corrective physical training, targeted physiotherapy, ergonomic adaptation of study environments, rational regulation of physical and digital loads, and continuous monitoring of spinal function. Such a multidisciplinary strategy allows interruption of the pathological cascade leading from reversible dysfunction to chronic musculoskeletal disease.

Conclusion:

Vertebrogenic pain syndromes in children are predominantly associated with functional spinal disorders, muscular imbalance, and postural instability intensified by modifiable lifestyle factors. Clinical assessment combined with instrumental diagnostics enables early identification of pathological changes and accurate determination of disease severity. Timely correction of risk factors, implementation of individualized rehabilitation programs, and optimization of educational ergonomics significantly improve clinical outcomes and reduce the risk of chronic musculoskeletal pathology in adulthood. Preventive measures aimed at promoting physical activity, postural hygiene, and balanced spinal loading should be considered a fundamental component of pediatric healthcare. Vertebrogenic pain syndromes in children develop mainly under the influence of correctable biomechanical and lifestyle-related factors and are most often characterized by functional rather than permanent structural abnormalities. The integration of thorough clinical evaluation with modern instrumental diagnostics enables accurate identification of early pathological changes and objective assessment of disease severity. Timely elimination of contributory conditions, together with individualized rehabilitation and postural correction programs, significantly improves functional recovery and minimizes the risk of long-term complications. The implementation of preventive strategies focused on physical activity optimization, postural hygiene, and balanced spinal loading should be regarded as a key priority in pediatric health protection.



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