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Postural Disorders of the Spine in Children and Adolescents: Risk Factors and the Effectiveness of Corrective Interventions

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Abstract: Postural disorders in children and adolescents are an emerging public health concern linked to sedentary lifestyles, prolonged use of technology, and insufficient physical activity. These conditions, often manifesting as kyphosis, lordosis, or scoliosis, can lead to long-term musculoskeletal dysfunction if not identified and corrected early. Methods: This comparative narrative review analyzed 40 scientific studies published between 2009 and 2025, focusing on posture, spinal sagittal alignment, proprioception, and balance in children and adolescents. The included studies assessed the efficacy of corrective interventions such as exercise programs, postural education, and electrical stimulation. Literature searches were conducted in PubMed, Google Scholar, PEDro, and ScienceDirect databases using keywords related to spinal deformities, postural deficits, and rehabilitation strategies. Results: Postural control improves progressively with age, independent of the number of postural disorders, reflecting the adaptability of the neuromuscular system. However, sedentary behavior and body weight remain major determinants of postural disorders. Adolescents with thoracic deformities show altered proprioception, mobility, and balance. Evidence supports the effectiveness of functional and proprioceptive exercise programs, including core stabilization and postural education, in improving spinal curva-ture, body awareness, and self-esteem. Conclusions: Spinal postural disorders in youth result from the complex interaction of biomechanical, neuromuscular, and behavioral factors. Early intervention through integrated educational and physiotherapeutic interventions is essential to prevent progression and promote musculoskeletal health.

Keywords: postural disorders, spine, children, adolescents, kyphosis, lordosis, flat back, scoliosis, risk factors, interventions, corrective exercises

1. Introduction

Proper spinal posture is essential for the harmonious physical development of children and adolescents. Postural imbalances result from genetic, biomechanical, functional, and behavioral factors, including sedentary habits and improper daily posture [1]. Posture reflects body alignment in space and plays a crucial role in maintaining balance during movement and rest [1,2].

Postural disorders in youth are a public health concern because they predispose individuals to spinal degeneration and musculoskeletal disorders later in life. In a cross-sectional study of 508 students, 79.3% presented postural changes on the Adam's test, mainly affecting the neck, shoulders, lumbar region, and knees [3]. The high rate of musculoskeletal symptoms highlights the need for early preventive and corrective actions, considering gender differences [4].

Dop et al. recently reported rising rates of postural disorders linked to sedentary lifestyles and poor posture. Among 134 children aged 5–18, 76% were underweight, 21% had scoliosis, 7.5% kyphosis, 1.5% lordosis, and 70% combined defects. Factors such as rickets sequelae, incorrect sitting, asymmetrical backpack use, and poor diet were strongly associated with these issues, emphasizing the importance of early prevention [5].

Adolescence is a sensitive developmental stage marked by growth spurts, maturation, and behavioral changes [6]. High screen time increasingly shapes habits, reducing physical activity, disturbing sleep, and worsening postural disorders and musculoskeletal strain [7].

Postural control depends on muscle activation and elastic properties that stabilize segments and determine tone and alignment, despite minimal muscular activity [8]. Balance is maintained through anticipatory and compensatory adjustments, the former increasing with perturbation intensity and the latter remaining relatively stable [9]. Quantitative assessment uses center-of-mass and pressure analyses via baropodometry and EMG, while qualitative evaluation examines biomechanical and neurophysiological mechanisms underlying balance [10,11].

Evidence suggests postural disorders —kyphosis, lordosis, scoliosis—arise from both structural and modifiable dynamic factors such as impaired proprioception, neuromuscular imbalance, and sedentary behavior. Adolescence represents a key window for intervention due to high neuromuscular adaptability. Early corrective strategies combining exercise, postural education, and proprioceptive training are expected to enhance alignment, improve balance, and support long-term musculoskeletal health.

This narrative review synthesizes current findings on biomechanical, neuromuscular, and behavioral determinants of postural disorders in youth and evaluates the effectiveness of corrective approaches such as exercise programs, postural education, and neuromuscular re-education. The aim is to inform evidence-based prevention and rehabilitation initiatives in pediatric and school settings.

2. Materials and Methods

Literature Review and Methodology

To clearly define the scope and direction of this review, the research question was formulated according to the PICO framework (Population, Intervention, Comparison, and Outcome). The population (P) consisted of children and adolescents aged 6 to 22 years who presented with postural disorders or spinal misalignments, such as kyphosis, lordosis, flat back, or postural scoliosis. The interventions (I) investigated in the selected studies comprised corrective and preventive strategies, including specific exercise programs, postural education, proprioceptive training, and electrical stimulation, all aimed at improving posture, spinal alignment, and balance.

When applicable, the comparison (C) was made with control groups who either did not receive any corrective intervention or participated only in routine physical education programs, allowing an evaluation of the relative effectiveness of targeted

rehabilitation methods. The primary outcomes (O) considered were improvements in postural alignment, spinal sagittal balance, proprioceptive control, and functional stability, as well as the reduction of compensatory asymmetries and pain symptoms.

Exclusion criteria included: (1) studies focusing exclusively on adults, elderly populations, or infants; (2) research addressing congenital spinal deformities requiring surgical correction, without a functional or conservative component; (3) papers analyzing postural assessment tools or screening systems without reporting clinical, biomechanical, or functional outcomes; (4) case reports, conference abstracts, dissertations, and non–peer-reviewed publications; (5) studies lacking essential methodological information (sample characteristics, intervention description, outcome measures); and (6) duplicate datasets or secondary analyses of previously included studies.

Screening was performed in two stages. First, titles and abstracts were reviewed to identify potentially relevant studies. Second, full texts were examined to confirm eligibility according to the predefined criteria. Any discrepancies between reviewers were resolved through consensus. This approach ensured that the final body of evidence included in the narrative synthesis was both methodologically sound and directly relevant to the objectives of the review.

The review encompassed experimental, cross-sectional, meta-analytical, and narrative studies published between 2009 and 2025, written in English, Polish, Portuguese, or Japanese. This framework enabled a systematic synthesis of current evidence regarding the risk factors contributing to postural disorders and the efficacy of corrective interventions among pediatric and adolescent populations.

For literature retrieval, controlled vocabulary (MeSH terms) and free-text keywords were used to ensure comprehensive coverage of the topic. The main descriptors included: *posture*, *postural balance*, *spinal curvatures*, *kyphosis*, *lordosis*, *scoliosis*, *postural scoliosis*, *child*, *adolescent*, *proprioception*, *exercise therapy*, *rehabilitation*, *postural education*, *electric stimulation therapy*, *musculoskeletal development*, and *risk factors*. These terms were combined using Boolean operators to maximize sensitivity and specificity across the PubMed, ScienceDirect, PEDro, and Google Scholar databases.

3. Results

3.1. Biomechanical and Functional Analysis of Posture

Recent literature provides a comprehensive biomechanical and functional perspective on posture in children and adolescents (Table 1). Permoda-Białozorczyk et al. (2022) [12] demonstrated that proprioceptive control improves significantly with age in children with postural disorders, while the number of such defects does not influence proprioceptive capacity. Similarly, Kłapeć et al. (2025) [13] identified multifactorial etiologies in spinal deformities, emphasizing the combined effects of genetic predisposition, environmental exposure, and hormonal imbalances, particularly those related to vitamin D deficiency, in the development of scoliosis.

Research on neuromuscular regulation by Haavik et al. (2021) [14] revealed that spinal dysfunctions, defined as central segmental motor control (CSMC) disturbances, alter neuromuscular activation patterns. The study further showed that high-velocity, low-amplitude (HVLA) spinal adjustments can modulate neuromuscular control and functional stability.

In relation to static balance, Azevedo et al. (2022) [15] found that sagittal spinal angles are poor predictors of stabilometric parameters, suggesting that sensorimotor and vestibular mechanisms have a greater influence on balance than spinal geometry alone. Poussa et al. (2022) [16] noted a critical gap in longitudinal research, highlighting the absence of cohort studies that follow spinal posture development across the entire pubertal growth phase.

Body composition has also emerged as a relevant determinant of postural health. Grabara et al. (2024) [17] reported that maintaining optimal body composition significantly reduces the risk of developing spinal curvature abnormalities. Finally, Du et al. (2023) [18] underlined the strong relationship between postural imbalance and

low back pain, noting that faulty posture is a major risk factor for lumbar pain and that systematic postural assessment is essential in prevention and clinical management.

Collectively, these studies emphasize that posture control and spinal alignment in youth are shaped by a complex interplay of biomechanical, neuromuscular, and physiological factors, and that early screening combined with targeted corrective interventions is essential for long-term musculoskeletal health.

Table 1. Scientific articles presenting studies that perform biomechanical and functional analysis of posture.

Type of Intervention / Analysis	Year	Author	Type of Deficiency	Main Results
Analysis of proprioceptive control	2022	Permoda-Białozorczyk A. [12]	Postural disorders in children	Proprioceptive control increases significantly with age; the number of postural disorders does not influence the level of proprioceptive control.
Etiological analysis (genetic, environmental, hormonal factors)	2025	Kłapeć W. [13]	Vertebral deformities (scoliosis)	Scoliosis is influenced by genetic predispositions, environmental factors, and hormonal factors (e.g., vitamin D).
Analysis of neuromuscular regulation; HVLA adjustments	2021	Haavik H. [14]	Spinal dysfunctions (CSMC)	Spinal dysfunctions affect neuromuscular control; HVLA spinal adjustments can modify neuromuscular function.
Analysis of the relationship between postural parameters and static balance	2022	Azevedo N. [15]	Static/postural imbalance	Sagittal spinal angles poorly predict stabilometric variables; other factors determine balance control.
Longitudinal analysis (review)	2022	Poussa M.S. [16]	Postural changes during puberty	There are no cohort studies examining the evolution of spinal posture throughout the entire pubertal growth period.
Analysis of body composition	2024	Grabara M. [17]	Abnormal spinal curvatures	Maintaining optimal body composition reduces the risk of developing an abnormal spinal curvatures.
Analysis of spinal posture in relation to low back pain	2023	Du S.H. [18]	Low back pain (lumbalgia)	Postural imbalances are major risk factors for low back pain; postural assessment is essential in its management.

3.2. Deficiencies of the Thoracic Wall and Spine

Adolescents presenting with thoracic deformities are at an increased risk of developing spinal alignment, mobility, and proprioceptive disorders compared to their peers without such abnormalities. Therefore, early clinical identification and multidisciplinary management are crucial for preventing long-term biomechanical and functional complications [13-18].

Effective management of these deformities requires close collaboration between pediatric surgeons and physiotherapists, focusing on correcting alignment deficits, restoring mobility, and improving proprioceptive control through targeted rehabilitation programs. As suggested by [19], assessment should not be limited to the thoracic region alone but should encompass a comprehensive evaluation of spinal structure and function, integrating orthopedic, neurological, and physiotherapeutic perspectives to ensure an individualized treatment approach.

Currently, no universally accepted classification system for kyphotic spinal deformities provides both consistent diagnostic criteria and clear therapeutic guidance. A previous study proposed a framework incorporating spinal deficits, intervertebral disc flexibility, curvature magnitude, and its correlation with the type of corrective osteotomy required, offering a more functional and surgery-oriented perspective [20].

Recent analyses have also focused on the pathophysiological factors contributing to age-related hyperkyphosis and its broader health implications [21]. Given the adverse effects of hyperkyphosis on physical performance, quality of life, and even mortality, clinicians should address not only osteoporosis but also the progressive postural changes associated with aging, which may exacerbate spinal deformities.

Importantly, postural disorders should be clearly distinguished as functional or structural. Functional hyperkyphosis, hyperlordosis, and functional scoliosis can often be corrected or improved through conservative physiotherapeutic interventions once identified via thorough clinical assessment. In contrast, structural scoliosis poses a higher risk of painful and cardiopulmonary complications and necessitates rigorous monitoring and timely intervention [22].

3.3. Risk Factors for Spinal Postural Disorders

Recent studies report a high prevalence of postural alterations among school-aged children and adolescents, affecting nearly 65% of students, with the most common deviations involving the head, spine, hips, trunk, and abdomen (Table 2). These abnormalities are closely associated with insufficient physical activity, as well as socioeconomic and educational disparities within families, which influence health awareness and preventive behaviors [23,24].

These findings highlight the urgent need for school-based and community-level educational programs aimed at both children and parents, focusing on the prevention and correction of postural disorders and the promotion of healthy lifestyle habits that support musculoskeletal development.

Sex-related differences have also been identified: male students exhibit a lower prevalence of sagittal spinal deviations compared to females [25]. The high incidence of lumbar hyperlordosis, particularly among female students, underscores the importance of investigating modifiable risk factors—such as sedentary behavior, inadequate ergonomic conditions, and muscle imbalance—for integration into preventive health education programs [26].

Furthermore, age has been identified as the main determinant of sagittal spinal alignment in children, whereas body mass index and sports participation appear to exert no independent effects [27]. In addition, individuals diagnosed with scoliosis demonstrate notable proprioceptive deficits and postural instability, emphasizing the necessity of incorporating proprioceptive and balance training into rehabilitation programs to restore optimal postural control and functional stability [28].

Table 2. Scientific articles analyzing risk factors for spinal postural disorders.

Type of Intervention / Analysis	Year	Author	Type of Deficiency	Main Results
Observational study of students	2023	Resende B.B. [23]	Postural alterations	High prevalence of postural alterations; the head, spine, hips, trunk, and abdomen are most affected.
Comparative study	2013	Latalski M. [24]	Postural alterations	Findings support the prevalence of postural changes among students and pupils.
Gender-based comparative analysis	2024	Đorđević S. [25]	Sagittal spinal deviations	Male participants showed a lower prevalence of sagittal spinal deviations than female participants.
Observational / prevalence analysis	2012	Lemos A.T. [26]	Lumbar hyperlordosis	High prevalence observed; suggests the need to analyze modifiable variables for integration into health education programs.

Correlation analysis	2025	Annarumma G.[27]	Sagittal spinal alignment in children	Age is the main factor associated with sagittal spinal alignment; BMI and sports participation showed no independent significant effects.
Proprioceptive assessment	2025	Koura G. [28]	Proprioceptive deficits in scoliosis	Individuals with scoliosis have significant proprioceptive deficits correlated with postural instability; this highlights the importance of proprioceptive training.

3.4. Interventions and Corrective Exercises

Exercise programs emphasizing targeted physical activity, stretching, and neuromuscular control have demonstrated significant benefits for correcting spinal curvatures and improving postural stability (Table 3). Evidence indicates that functional corrective exercise programs can effectively reduce excessive thoracic kyphosis in adolescents [29], while combined exercise interventions contribute to enhanced spinal alignment and balance in individuals with postural kyphosis [30]. Approaches that integrate postural awareness training with corrective exercises for thoracic kyphosis appear particularly effective, and the inclusion of post-traumatic physiotherapy (PPT) may further amplify these outcomes [31].

In the case of lumbar hyperlordosis, trunk stability exercises (CSE), whole-body electromyostimulation (WB-EMS), and the combined CSE Plus protocol have all shown efficacy in correcting lumbar curvature and improving dynamic balance, with the CSE Plus program producing the most pronounced effects [32]. The ISQUIOS protocol has further contributed to this field by establishing normative reference values for postural conditions and introducing a standardized screening tool for the early detection of postural and functional deficits in children and adolescents, highlighting significant sex-related differences [33]. Moreover, multidimensional exercise programs coupled with postural education have been shown to improve body awareness, enhance self-esteem, and alleviate low back pain [34].

Table 3. Scientific articles analyzing interventions and corrective exercises.

Type of Intervention / Analysis	Year	Author	Type of Deficiency	Main Results
Functional corrective exercise program, randomized controlled trial	2018	Feng Q. [29]	Excessive thoracic kyphosis	Reduced excessive thoracic kyphosis in adolescents
Combined exercise program	2022	Park YJ. [30]	Postural kyphosis	Improved spinal alignment and balance
Corrective exercises + postural perception + PPT	2022	Elpeze G. [31]	Thoracic kyphosis	Effective intervention, with enhanced benefits when combined with PPT
CSE, WB-EMS, CSE Plus	2024	Shalamzari MH. [32]	Lumbar hyperlordosis	Corrected lumbar curvature and improved dynamic balance; CSE Plus had the greatest impact
ISQUIOS protocol, postural fitness assessment	2025	Martínez-Romero M.T. [33]	Postural screening in children/ adolescents	Established reference values, identified sex differences in postural and neuromuscular profiles
Combined exercises + postural education	2025	Mokhtaran S. [34]	Low back pain, poor body awareness	Improved body awareness and self-esteem, reduced low back pain

3.5. Assessment Techniques for Postural Evaluation

To strengthen methodological coherence, the most commonly used tools for evaluating posture in children and adolescents can be summarized as follows. Clinical screening methods remain central for the initial detection of deviations. The *Adam's Forward Bend Test* is widely used to identify asymmetries indicative of scoliosis, while the scoliometer provides a quick, non-invasive measure of trunk rotation (ATR), increasing screening accuracy in large populations.

Instrument-based assessments further quantify postural function. Stabilometry evaluates balance by analyzing center-of-pressure movements during quiet standing, offering insight into vestibular and proprioceptive regulation. Baropodometry complements this by assessing plantar pressure distribution and weight-bearing symmetry, which often reflects compensatory patterns in scoliosis, hyperkyphosis, or lower-limb imbalances.

More advanced systems, such as photogrammetry and 3D posture analysis allow precise, non-invasive measurement of spinal curves and segmental alignment, reducing subjectivity and enhancing reproducibility.

Together, these tools provide a comprehensive view of spinal alignment, balance, and neuromuscular control. Using multiple complementary assessments improves diagnostic accuracy and supports the development of targeted corrective interventions for youth with postural deviations.

4. Discussion

Postural disorders of the spine in children and adolescents represent a complex, multifactorial condition with important biomechanical, neuromuscular, and psychosocial implications. Their increasing prevalence in recent decades is largely attributed to lifestyle changes, reduced physical activity, and excessive use of technology [3,5,8,9].

4.1. Biomechanics and Neuromuscular Control

Proprioceptive control develops progressively with age, independently of the number of postural disorders [12], reflecting the adaptive capacity of the neuromuscular system. However, central segmental motor control (CSMC) dysfunctions can impair motor coordination and contribute to the persistence or worsening of spinal misalignments [14]. These findings highlight the need for interventions that target both the mechanical and neuromuscular aspects of posture through stabilization, balance, and postural awareness exercises. The weak correlation between sagittal spinal parameters and static balance [15] suggests that posture results from the complex interaction of sensory, musculoskeletal, and central mechanisms rather than from spinal geometry alone. Consequently, proprioceptive training and global postural re-education are essential components of both preventive and rehabilitative programs.

4.2. Thoracic and Spinal Deformities

Thoracic deformities affect not only appearance but also respiratory, cardiovascular, and musculoskeletal function. Therefore, a multidisciplinary approach involving pediatricians, physiotherapists, and orthopedic specialists is essential, as aesthetic correction alone is insufficient [14]. The lack of a standardized classification system for kyphotic deformities [15] hinders consistent treatment planning and contributes to interstudy variability. Distinguishing between functional and structural deviations remains critical: functional deformities often respond favorably to physiotherapy and postural re-education, whereas structural scoliosis requires careful monitoring and, in some cases, orthopedic intervention [22].

4.3. Risk Factors and Demographics

Sedentary behavior, excessive screen use, and increased body weight are strongly associated with postural disorders. The high prevalence observed in school populations (~65%) emphasizes the need for preventive educational initiatives and early

screening. Gender differences are consistently reported, with females being more susceptible to sagittal deviations, likely due to biomechanical and hormonal influences [25]. Age remains the strongest predictor of spinal alignment, underscoring the necessity of continuous monitoring throughout the pubertal growth phase [27].

4.4. Effectiveness of Interventions

Strong evidence supports the efficacy of functional, proprioceptive, and trunk-stabilization exercises in correcting spinal deviations [29–34]. Combined programs that integrate stretching, postural education, and neuromuscular training significantly reduce kyphotic and lordotic angles while improving balance, proprioception, and self-esteem. The ISQUIOS protocol offers a structured and standardized framework for early detection and personalized intervention in school environments [33]. Overall, early, integrative approaches that combine medical, educational, and physiotherapeutic components demonstrate the highest effectiveness, especially when parents and teachers are actively involved in maintaining postural habits.

4.5.Practical Implications

The findings of this review emphasize the importance of early screening and intervention programs within school and community settings. Regular postural assessments, combined with targeted exercise routines and postural education, can effectively prevent the progression of spinal deformities during critical growth periods. Implementing multidisciplinary rehabilitation protocols that involve physiotherapists, educators, and parents is essential to promote long-term adherence and postural awareness. Integrating proprioceptive and neuromuscular training into physical education curricula could significantly reduce the incidence of postural deviations and improve overall musculoskeletal health among children and adolescents [35].

4.6. Complementary Therapeutic and Preventive Approaches

Beyond traditional postural correction and proprioceptive training, recent studies have explored the use of alternative and complementary therapeutic modalities aimed at improving balance, coordination, and neuromuscular control. Badau (2017) demonstrated that structured aquatic exercise programs—including initiation in water gymnastics and swimming—produce favorable somatic, motor, and functional effects among physical education students, highlighting the role of hydrodynamic resistance in developing postural stability and overall physical conditioning [36].

Further evidence supports the integration of hydrokinetic therapy and physical therapy exercises in complex rehabilitation programs. Cotrobaș-Dascălu et al. (2022) reported significant improvements in balance, gait, and functional capacity among patients with lower limb amputation following combined land-based and aquatic physiotherapy, emphasizing the importance of multisensory feedback and progressive load adaptation in motor recovery [37].

In a broader preventive and rehabilitative context, Munteanu et al. (2021) underlined the necessity of tertiary prevention strategies in chronic conditions, such as glaucoma, through individualized exercise interventions that maintain functional independence and quality of life [38]. These findings reinforce the importance of continuous, multidimensional rehabilitation approaches that extend beyond musculoskeletal pathology.

The integration of digital and sensorimotor technologies into physiotherapy practice is also gaining increasing attention. Badau et al. (2023) demonstrated that Fitlight technology, which utilizes peripheral vision stimulation, enhances manual reaction time and visual-motor coordination in athletes, providing insights into neuromotor adaptability and proprioceptive efficiency [39]. Similarly, Badau et al. (2023) highlighted the benefits of therapeutic exergames, demonstrating that six weeks of interactive exercise significantly improved cognitive flexibility and reaction times, which correlated positively with manual and podal motor performance [40].

Together, these complementary approaches suggest that postural and motor rehabilitation should not rely solely on traditional exercise programs but rather adopt an integrated framework combining hydrotherapy, sensorimotor stimulation, and digital-assisted interventions. Such multidimensional strategies can enhance neuromuscular control, cognitive engagement, and functional outcomes, supporting a modern, evidence-based model of postural re-education and preventive physiotherapy.

4.7 Heterogeneity of Exercise Intervention Protocols

The reviewed studies exhibit substantial heterogeneity in exercise interventions, differing in duration, intensity, and modalities. Protocols range from short 4–6-week corrective programs [29–31] to longer 8–12-week or multi-phase interventions incorporating stabilization, stretching, or neuromuscular training [32–34]. Intensities vary from low-load mobility and flexibility work [29,30] to moderate-to-high intensity core stabilization, resistance training, and WB-EMS, particularly in trials evaluating CSE and CSE Plus protocols [32]. Modalities also differ markedly: some studies prioritize postural awareness and proprioceptive training [29–31], while others combine strengthening, balance exercises, thoracic mobility work, or multimodal approaches such as PPT and global postural re-education [31–34].

Despite this variability, several best-practice elements consistently emerge. Interventions integrating core stabilization, proprioceptive stimulation, and postural education produce the most robust improvements in sagittal alignment and balance across populations [29–34]. Programs lasting ≥8 weeks generally yield superior effects, suggesting that neuromuscular adaptation requires sustained training [32–34]. Multimodal approaches—those combining strength, mobility, and sensorimotor components—show the strongest outcomes for functional deviations such as hyperkyphosis and hyperlordosis [29–32]. Nevertheless, methodological diversity limits direct comparisons across studies, highlighting the need for standardized protocols and clearer reporting of exercise intensity and progression in future research.

4.7. Limitations and Future Directions

Despite encouraging findings, several methodological limitations persist. There is still a lack of large-scale, longitudinal studies that follow spinal posture development across puberty. Moreover, heterogeneity in postural assessment techniques and the absence of international standards reduce comparability across studies [15]. Future research should employ advanced technologies such as three-dimensional posture analysis, motion capture, and digital feedback systems to improve diagnostic accuracy and optimize intervention outcomes.

5. Conclusions

Spinal postural disorders in children and adolescents represent a multifactorial condition resulting from the interaction of genetic, biomechanical, neuromuscular, and behavioral influences. The findings of this review highlight puberty as a critical developmental phase for the onset and progression of postural imbalances, particularly under the influence of sedentary behavior and prolonged technology use. Identified risk factors — including age, sex, excessive body weight, and insufficient physical activity — reinforce the need for early detection, continuous monitoring, and timely intervention.

Evidence consistently supports that corrective interventions centered on functional exercises, neuromuscular control, and postural education are effective in reducing deviations such as kyphosis and lordosis, improving balance, proprioception, and psychological well-being. These findings advocate for the implementation of an integrated prevention and rehabilitation model, emphasizing multidisciplinary collaboration among physiotherapists, educators, physicians, and parents. Incorporating postural education and early screening programs within school environments may play a decisive role in reducing the long-term burden of spinal disorders and promoting optimal musculoskeletal health from childhood through adolescence.

Future research should focus on the development of longitudinal studies and the integration of advanced technologies — such as three-dimensional posture analysis and digital feedback systems — to enhance the precision of diagnosis, personalize interventions, and improve long-term postural outcomes.

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