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Brief Review

Educational Strategies for Spinal Health: Challenges and Perspectives in Preventing Low Back Pain in Youth

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Purpose: Given the growing prevalence of low back pain (LBP) starting in early adolescence, closely linked to prolonged sitting, poor posture, and physical inactivity, there is a need to introduce proactive interventions. The objective of this narrative review is to explore and synthesize existing knowledge on school-based educational programs aimed at spinal health and preventing poor posture.
Methods: A literature search was conducted across multiple databases using keywords related to school-based educational programs aimed at promoting spinal health.
Results: School-based interventions proved effective in raising awareness of spinal health and promoting healthy postural behaviors. Programs that combined physical activity with interactive, student-centered learning showed the most significant promise. Most studies focused on children aged 6-12, despite LBP often beginning during adolescence. Existing interventions were frequently short-term and teacher-centered. There was a growing need for long-term, curriculum-integrated, student-centered programs that measured both knowledge retention and behavioral outcomes. Furthermore, many studies lacked methodological rigor, underscoring the importance of well-designed, randomized controlled trials that utilize validated tools. Insufficient attention was also given to digital methods, teacher training, and interdisciplinary approaches.
Conclusions: School-based interventions have proven effective in raising awareness of spinal health, with programs that integrate physical activity and interactive, student-centered learning showing the greatest potential for promoting healthy postural behaviors. However, inconsistent implementation and reliance on individual educators revealed the need for systemic change. Integrating postural education into school health curricula- supported by digital tools and cross-sector collaboration- was recognized as a way to improve long-term student health and serve as a meaningful public health initiative.

Keywords: child, adolescent, spine, postural education, health promotion

Introduction

Low back pain (LBP) is the most common cause of disability worldwide.[1] LBP often begins in childhood, and in adolescents, the prevalence is similar to that of adults. Epidemiological data indicate that the lifetime prevalence of LBP in youth can vary widely depending on the type of prevalence measure used (e.g., point, period, or lifetime prevalence).[2-5] As research shows, both period and lifetime prevalence rates of LBP in children and adolescents were notably higher than point prevalence. Specifically, the mean lifetime prevalence was 39.9% (95% CI: 34.2%–45.9%), the mean 12-month period prevalence was 33.6% (95% CI: 26.9%–41.0%), while the 1-week prevalence reached 17.7% (95% CI: 12.4%–24.7%).[5] In children and adolescents, most episodes are brief, mild, and do not interfere with daily functioning. However, questionnaire-based research and follow-up studies showed that 31% of students aged 8 to 18 years experience a recurrence of back pain within one year.[6-8] Research suggests that the prevalence of LBP in children and adolescents increases with age, ranging from 13.2% among students aged 10–11 years to as high as 61.4% among those aged 18–19 years.[4,9-11]
Known risk factors for LBP include heavy backpacks, prolonged sitting, poor ergonomics, and inadequate posture to carry out activities such as writing, using the computer, and picking up objects from the ground.[10] Moreover, studies have found that back pain in teenagers is associated with physical inactivity.[12-14] Health education research has primarily focused on highlighting the benefits of physical activity (PA) and providing recommendations regarding the type and amount of exercise necessary to achieve a healthy lifestyle and enhance PA adherence.[15-17] A systematic review assessing the effectiveness of PA in the management of nonspecific LBP found that stabilization exercises appear particularly effective for reducing pain, and central stabilization exercises show benefits for proprioception.[18] These findings align with WHO recommendations, which specifically advocate for physical activity that enhances strength, flexibility, balance, and coordination.[16]
The systematic review conducted by Salsali et al.[18] reported no significant association between overall PA levels and body posture. However, other studies indicated a correlation between the occurrence of back pain and body posture or inadequate

sitting posture, particularly during tasks such as writing or computer use.[2,19,20] Students who remain seated for prolonged periods, often adopting poor postural habits characterized by forward trunk flexion, insufficient lumbar support, and lack of forearm support, are at increased risk of developing various musculoskeletal complaints. These include generalized discomfort, pain, fatigue, and paresthesia in different body regions. Prolonged exposure to biomechanical stressors may contribute to the development of degenerative spinal conditions, such as intervertebral disc herniation. Human physiology is inherently designed for movement rather than static postures, and variability in movement patterns is not only natural but essential for optimal function and health. This concept aligns with the principle of "movement variability", one that emphasizes the importance of joint-specific mobility and stability ("joint-by-joint approach").[22] These findings underscore the need to adopt a new paradigm of "posture change" and to address ergonomic factors within educational environments, particularly in relation to the sedentary behaviors commonly observed among school-aged children and adolescents.

Multiple biopsychosocial factors may influence human posture, potentially explaining the observed outcomes. It is a crucial area that warrants greater attention in health education initiatives.[23] Promoting healthy behaviors in childhood is more effective and feasible than attempting to change entrenched unhealthy habits in adulthood. Consequently, early prevention and identification of modifiable risk factors are becoming increasingly important.[24] The rising incidence of musculoskeletal problems among children, along with evidence that early-onset LBP often predicts future impairment, underscores the need for proactive interventions. Schools, where children spend most of their daytime hours, are an ideal setting for such programs.

Primary prevention (Level I) aims to reduce the risk of health issues by addressing and eliminating potential causes. Educational programs implemented within the school environment should be a cornerstone of these strategies. In this regard, schools play a fundamental role in health promotion by instilling lifelong healthy habits.

Theoretical frameworks suggest that teaching children about spinal anatomy, posture, and proper lifting mechanics can significantly reduce the risk of injury and musculoskeletal pain. However, despite widespread interest, no standardized global guidelines currently exist for school-based spinal health programs.[25] Most initiatives remain local or pilot projects, often developed by researchers. These programs vary widely in content and instructional methods.[25,26]

Cumulative low back load, such as that resulting from prolonged sitting, is a well-documented risk factor for the development of LBP.[27] The school environment, particularly during lessons, is often the first setting where children are exposed to extended sedentary behavior. To address this, some schools have introduced environmental modifications, such as standing desks and classroom design adjustments, to encourage more ergonomic behavior.[28,29] While such solutions can be expensive and challenging to implement universally, there is growing awareness among educators about the importance of interrupting long sitting periods. Many have started incorporating active breaks from the early years of primary education.[30]

Movement-based interventions, including classroom activity breaks, have been shown to mitigate the adverse effects of prolonged sitting and promote dynamic posture throughout the school day. These initiatives were sometimes complemented by computer-based programs and ergonomics-focused exercises designed to reinforce correct body mechanics.[31-33] Despite these advances, many educators still preferred a seated classroom model, considering it the most efficient method for delivering the curriculum.[34] However, prolonged sedentary behavior is often associated with decreased attention and concentration among students, commonly observed as restlessness or fidgeting. Moreover, structural challenges such as limited classroom space, high student-to-space ratios, and poorly designed furniture further promote extended sitting and complicate the adoption of movement-friendly teaching methods.

The objective of this narrative review is to explore and synthesize existing knowledge on school-based educational programs aimed at spinal health and preventing poor posture. The review seeks to identify the types of interventions, target age groups, teaching methods, and reported outcomes, as well as to highlight gaps in the current literature and suggest directions for future research.

Materials and Methods

A literature search was carried out in March 2025. The following databases were searched: PubMed, SPORTdiscus and Medline (EBSCO), and Web of Science, with a search period from 1st January 2000 to 31 March 2025. The following keywords were used in combination with the Boolean operators AND and OR: "school-based health education", "posture education", "spinal health promotion", "back care education", "ergonomics in schools", "preventive programs for posture". These terms were combined with population-specific keywords such as "children," "adolescents," and "school-aged population," and outcome-related terms such as "effectiveness," "knowledge improvement," and "behavioral change." To ensure the relevance and consistency of the reviewed literature, specific inclusion and exclusion criteria were established. This review included scientific articles that describe educational programs implemented in school settings. Only studies involving school-aged children and adolescents were considered. Studies were excluded if they described rehabilitation programs conducted outside of the school environment or clinical interventions unrelated to educational contexts. Additionally, publications that lacked a clear description of the intervention or educational methods were not included in the review. Articles published between 2000 and 2025 were included in this review.

Results

Educational Intervention

Studies have identified four main types of interventions: (i) exercise, (ii) education, (iii) a combination of exercise and education, and (iv) ergonomic furniture.[25,36-38] Educational programs typically included components such as spinal anatomy, ergonomic principles, proper sitting posture, and correct schoolbag use. The combined approach—integrating both exercise and education—was found to be more effective than education alone, likely due to the synergistic benefits of physical activity and knowledge-based strategies within school-based spinal health interventions.

An essential aspect of many interventions is the involvement of parents and teachers, which helps to reinforce positive behaviors at school and home.[24,26] Pedagogically, most reported programs have used a teacher-centered, didactic approach, operationally defined as lessons delivered primarily through lectures, demonstrations, and supervised practice led by expert instructors (e.g., physiotherapists or physical education teachers), with students playing a passive role and the teacher being the main source of information. Measurement criteria for this approach include: (i) the proportion of instructional time spent in lecture versus practice, (ii) the extent of direct teacher control of activities, and (iii) the absence or minimal use of student-led or peer-based learning methods.[25,26] In the few trials (all conducted in primary schools, with participants aged ~6–12), researchers observed that lessons were delivered by expert instructors, often physiotherapists or physical education teachers (PE teachers), using lectures, demonstrations, and supervised exercises.[38] PE teachers occasionally led sessions, and some interventions included take-home materials (videos or booklets) to strengthen parental involvement. One recent program employed a blended model in which sports scientists trained classroom and PE teachers, conducted an awareness campaign for students and parents, and provided ongoing teacher support throughout the semester. Such reinforcement by teachers and parents is considered crucial for sustaining behavioral changes and ensuring that ergonomic knowledge acquired in the classroom translates into healthier postural habits at home as well.[39]

Also, the literature review in the field of educational programs indicated that teachers have insufficient and improper back health knowledge. However, all educational interventions increased awareness and understanding among teachers.[37,39-42] In many countries, teachers are rarely adequately trained to deliver health education. There is a need to introduce a comprehensive strategy that aligns with international recommendations and involves the entire school community in the health education process.[43]

Ongoing professional development focused on health education frameworks, current health knowledge, and pedagogical skills is essential to maintain teachers' engagement in this area. Present-day curricula tend to favor traditional approaches to health education rather than adopting a holistic perspective.[44] According to recommendations from the WHO and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), it is crucial to provide training for both future and current teachers on key topics related to children's health. Health education should be integrated into school curricula either within science subjects or as a standalone subject offered through extracurricular activities under the guidance of school staff.[45]

Effectiveness of Educational Interventions

Overall, school-based interventions demonstrated the most effectiveness in enhancing students' knowledge of spinal health and, to a lesser extent, improving postural behaviors.[24,38] For instance, a Portuguese program involving a single 90-minute session led by a physiotherapist resulted in a statistically significant increase in ergonomic knowledge by 3.91 points (95% CI: 3.49–4.33) with a very large effect (Cohen's $d = 1.93$), from a mean scores 9.1 to 13.0, $P < .001$.[37] Similarly, a systematic review conducted by Miñana-Signes et al.[38], which focused on randomized controlled trials (RCTs) conducted in Spain, reported that all intervention groups showed significant post-intervention gains in back-health knowledge. Participants frequently demonstrated improved recall of key educational messages and exhibited better posture during lifting and sitting tasks immediately following the intervention. Interventions focusing solely on exercise produced the most significant short-term improvements in spinal health, indicating a substantial decrease in LBP intensity following the exercise intervention ($P < .00001$), as well as a positive effect on LBP frequency (mean difference: − .80; 95% CI: −1.47 to − .13). Combined exercise and education programs demonstrated a moderate impact.[25] Specifically, the combination of exercise and education resulted in a reduction in LBP prevalence in intervention groups compared to control groups (odds ratio: .51; 95% CI: .35 to .73).[25]

However, the evidence supporting the effectiveness of educational interventions in preventing or reducing LBP remains limited and inconclusive. While some RCTs have reported short-term reductions in the prevalence or intensity of LBP, others have found no significant change.[26,38] A review by Anyachukwu et al.[26] concluded that educational interventions consistently enhanced students' knowledge and improved posture-related behaviors. Nevertheless, the evidence regarding their impact on reducing the prevalence of back pain remains inconclusive. Similarly, the review by Brink et al.[25] showed that education-only interventions exerted the weakest effect on spinal pain outcomes. These findings suggest that brief educational sessions may be insufficient to influence the occurrence of back pain, particularly given the multifactorial nature of adolescent LBP, which may involve growth-related, biomechanical, and psychosocial factors.

Notably, the inclusion of exercise components appears to enhance program outcomes. As highlighted in the review by Brink et al.[25], combining educational content with back-strengthening exercises led to greater improvements in reported mobility and pain reduction compared to education alone. Additionally, educational interventions have been effective in addressing modifiable risk factors. For example, students who receive instruction on proper backpack use subsequently demonstrate improved carrying techniques and ergonomic awareness during follow-up assessments ($\leq .001$).[37] Therefore, if pain reduction is a primary objective, interventions should not be limited to information dissemination alone, but rather incorporate physical training components and behavior change strategies to promote sustained musculoskeletal health.

Methodological Quality of Studies

The current evidence base for school-based back health programs remains limited in size and uneven in methodological quality. Systematic reviews consistently emphasize that the available evidence is both limited in scope and of low to moderate methodological quality.[25,26,38] Sample sizes were often small, usually involving only a few dozen students from one or two schools, which makes it hard to apply the results more broadly. Almost none of the studies were double-blinded (impractical for educational interventions), and follow-up was typically short.[25] Anyachukwu et al.[26] found that included RCTs varied greatly in risk of bias (PEDro scores ranged widely), and pointed to inconsistent use of validated outcome measures as a limitation.

Another issue is that most programs were teacher-led and rely on traditional, lecture-style teaching. As Miñana-Signes et al.[38] observed, none of the reviewed RCTs used a truly student-centered or constructivist approach. It means students were often passive participants, which may limit how much they learn and apply. In this context, we define student-centered pedagogy operationally as an instructional model where students actively engage through problem-solving, peer collaboration, and experiential tasks, rather than being passive recipients of knowledge. Measurement frameworks for such approaches should include (i) structured observation of student participation, (ii) validated engagement scales, and (iii) objective assessments of skill acquisition and application in daily life. Few studies have measured behavior change using objective tools, such as posture, which was usually self-reported or judged by teachers rather than measured with sensors or standardized scales.[38] Thus, long-term adherence and impact remain unknown. The lack of such measurement frameworks makes it difficult to evaluate whether observed improvements reflect true behavioral change or simply short-term knowledge acquisition. Only a few of the RCTs included a 3-month follow-up, and none followed students into later school years.[38] As a result, long-term adherence and sustained impact are largely unknown.

Finally, differences in program content and evaluation methods make it difficult to compare results. Some programs lasted only one day, while others ran for several months. Health professionals led some, while classroom teachers led others. Because of this variation, some systematic reviews avoid meta-analysis.[26,38] Recent reviews have called for the use of standardized, validated tools to measure outcomes and have noted that inconsistent outcome selection makes it difficult to draw firm conclusions.[26,38]

Integration into School Systems

Despite the potential, spinal health education was rarely a formal part of school curricula. There were a few national programs. Most initiatives were pilot projects or research studies. In practice, implementation depends on individual schools or districts. Miñana-Signes et al.[38] have argued that to achieve lasting impact, back care education should be "longitudinal and compulsory" within the school curriculum. The Anyachukwu et al.[26] review similarly advocates incorporating back care into regular schooling, noting that curricular integration has reduced pain incidence in some contexts. In Switzerland, a national pediatric guideline issued in 2022 recommended the inclusion of spinal care education within school health programs, although its implementation remains limited.

To date, where programs exist, they often involve collaboration between the education and health sectors. For example, in Portugal, "school physiotherapy" programs have been initiated in select regions, with physiotherapists delivering sessions on posture and core muscle training directly within schools.[37] In Spain, the service-learning model described earlier engaged physiotherapy students in providing health education to schoolchildren, thereby integrating community health resources into the educational environment.[46] These interdisciplinary models highlight promising pathways for future development.

However, to date, no global agency (WHO, UNESCO, etc.) has mandated the inclusion of spinal health education in schools. While the WHO's Global School Health policies emphasize general PA and musculoskeletal awareness, the development of specific curricula addressing posture and spinal care is typically left to national or regional discretion. In summary, existing programs are fragmented; making them a routine part of education would require policy changes and teacher training.

Innovations: Digital Technologies, Interactive Didactics, and Interdisciplinary Approaches

Emerging research is beginning to investigate innovative approaches to spinal health education in schools. In particular, digital and remote interventions have gained interest, especially in the context of post-COVID educational environments. A recent RCT conducted in Korea evaluated a six-week Digital Health Corrective Posture Exercise (DHCPE) program delivered remotely via screens, comparing its effectiveness to traditional face-to-face instruction.[47] The study found comparable improvements in head and shoulder posture across both groups, indicating that well-designed digital interventions- delivered through tablets, webcams, or similar platforms-may offer scalable solutions for school-based implementation. However, while promising, the study's methodology warrants critical appraisal. The intervention relied heavily on self-reported adherence and video-based monitoring, which may introduce reporting bias and reduce reliability compared to in-person supervision. In addition, the cluster randomization at the class level raises the possibility of contamination between groups, as students may have shared knowledge or exercises outside the assigned modality. Potential confounding variables, such as differences in baseline physical activity, ergonomic environments at home, or parental support, were not fully controlled, limiting the generalizability of results. Moreover, claims regarding scalability should be interpreted with caution, as no formal economic evaluation or feasibility analysis was conducted. Without data on cost-effectiveness, infrastructure demands, and sustainability, the practicality of large-scale implementation remains uncertain.[48] Nonetheless, issues related to access, technological infrastructure, and cost remain key challenges. Other technology-enhanced methods have been proposed in the literature, such as mobile applications for posture monitoring or game-based exercises. Recent advances in wearable technology integrated with artificial intelligence further expand these possibilities: AI-based biomechanical analysis can enhance posture detection, provide individualized feedback, and support injury prevention strategies, thereby offering a promising complement to school-based programs.[48] Yet, these approaches similarly lack robust trials with rigorous methodological safeguards, particularly regarding blinding, standardized adherence tracking, and long-term follow-up.[47] However, robust clinical trials evaluating their effectiveness are still lacking.

Interactive pedagogical strategies represent another promising direction. Rather than passive lectures, programs could use active learning: peer teaching, role-play (students practice loading/unloading backpacks), or classroom games that reinforce ergonomics. The service-learning model described by Calvo et al.[5] exemplifies this by positioning students as active participants rather than passive recipients of information. Integrating cross-disciplinary content- such as teaching the physics of levers in the context of safe lifting techniques- may also enhance conceptual understanding. However, most published interventions have not implemented such approaches. Miñana-Signes et al.[38] explicitly advocate for a shift toward constructivist, student-centered pedagogies to improve learning outcomes and engagement.

Interdisciplinary collaboration further enhances the potential impact of school-based back health initiatives. Programs that include physical education teachers, school nurses, parents, healthcare professionals, or students are better positioned to address the multifactorial nature of musculoskeletal health. For instance, the Spanish telematic Postural Education Program (PEPE) engaged multiple stakeholders —including classroom teachers, PE teachers, administrators, and families—and provided training not only to students but also to school staff.[39] Although the study did not observe significant posture improvements, its model of whole-school involvement serves as a valuable framework for future efforts. Similarly, health-promoting school models and partnerships that bring physiotherapy or ergonomics students into the classroom represent feasible ways to embed expert knowledge into educational settings. While logistical and financial barriers remain, such interdisciplinary strategies may contribute to more comprehensive and sustainable program implementation.

Proposed Integrated School-Based Intervention

Based on the results of our two previous studies[49,33], we propose an integrated school-based intervention to promote spinal health and improve postural behavior in children and adolescents. This intervention is conceptually aligned with the joint-by-joint training approach (JBJTA).[50] In this framework, optimal spinal health is not achieved through isolated posture correction, but through dynamic postural adaptation. By incorporating movement sequences that activate the hips, lumbar spine, and core musculature, the proposed program supports biomechanical efficiency and reduces compensatory loading patterns that contribute to spinal discomfort and dysfunction.

The program includes two key components: (1) weekly educational sessions on spinal anatomy, ergonomics, and posture, and (2) a daily routine of regular active breaks and hamstring flexibility exercises. Active breaks are performed every 30 minutes of sitting and include short sequences (30–60 seconds) of simple lumbar and hip extension exercises. These exercises are designed to reduce musculoskeletal discomfort, reduce static loading, and encourage maintaining an upright posture. The program also includes active hamstring stretching exercises combined with core stabilization and education regarding the maintenance of a neutral lumbar spine during activities (Figure 1). The educational part of the program focuses on building awareness and practical understanding, while the movement part helps reduce physical strain and support spinal function. This combination of education and movement addresses both cognitive and biomechanical risk factors for back pain, helping students develop daily habits that support long-term spinal health. The program is intended for use in both primary and secondary schools.

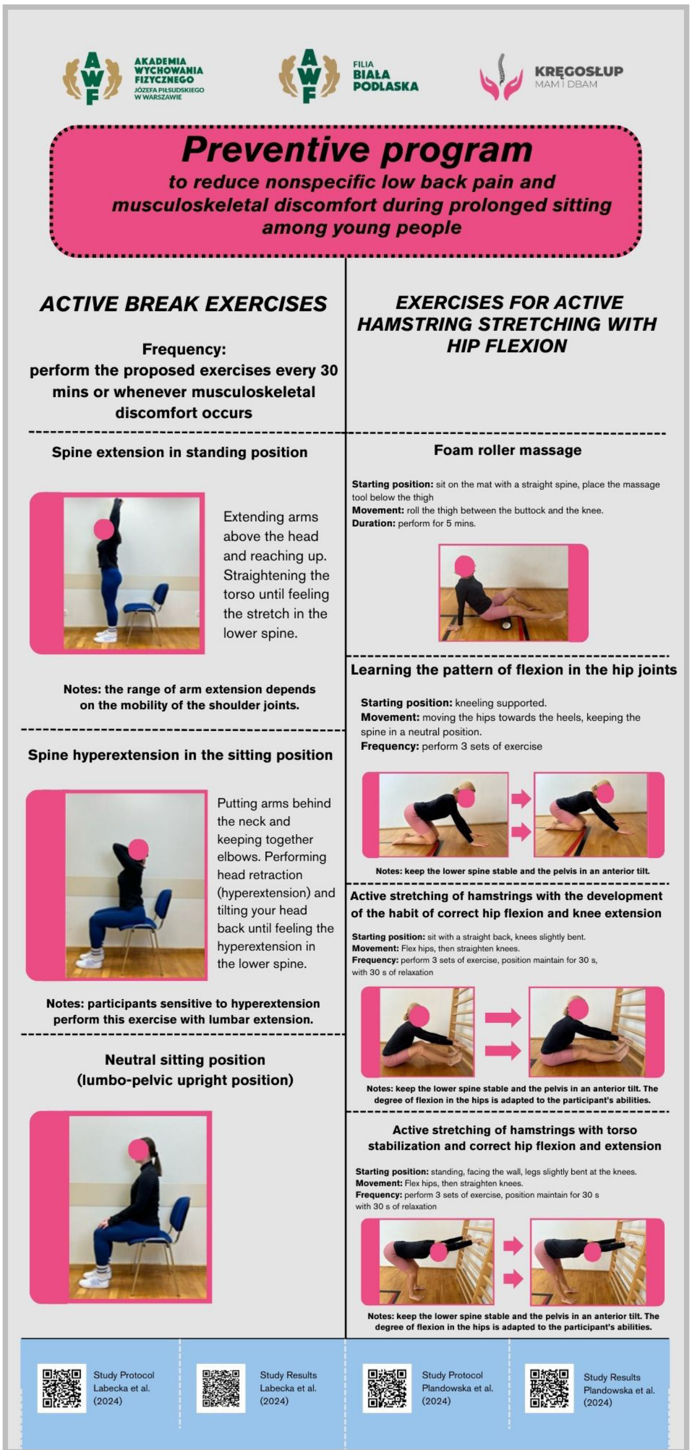

Figure 1. Infographic of the integrated school-based intervention.

Research Gaps

Several critical gaps remain in the current literature on school-based spinal health education. Epidemiological studies indicate that nearly 40% of children and teenagers have experienced back pain at some point, with older youth reporting it more often.[4,6,9-11] This pattern highlights the need to include spinal health education not only for younger children (ages six to twelve), but also for students in middle and high school, who may be more vulnerable due to physical development, lifestyle habits, and environmental influences.[38]

Second, many programs are limited to single or short-term sessions, which may yield only temporary benefits. Future studies should evaluate longitudinal and curriculum-integrated interventions, with follow-up assessments extending into later school years. One authoritative review recommends that spinal health education become a mandatory and continuous component of school curricula.[38]

Third, most interventions to date have employed traditional, teacher-centered delivery methods. Future programs should adopt student-centered pedagogies, such as interactive learning, educational games, peer-led instruction, and problem-solving approaches. These methods should be assessed not only for knowledge acquisition but also for their impact on behavioral change and long-term retention.[38]

Fourth, rigorous study design remains a major priority. There is a need for larger, well-powered randomized controlled trials or cluster-RCTs that incorporate clear randomization procedures, blinding of outcome assessors, and the use of standardized, validated measurement tools.[38] Future studies should include a priori power calculations based on expected effect sizes and clearly defined primary and secondary outcome measures. These methodological elements are essential to ensure the internal validity, reproducibility, and clinical relevance of findings in school-based spinal health interventions.

Fifth, greater exploration of digital and innovative delivery formats is warranted. Mobile applications, web-based learning modules, and exergames are emerging as feasible alternatives to in-person instruction, with early evidence[47] suggesting comparable effectiveness. Technologies such as wearable biofeedback sensors to detect slouching and virtual reality (VR) modules could also enhance engagement and learning in classroom settings. However, current studies rarely incorporate implementation science frameworks to assess the feasibility, scalability, and sustainability of digital interventions. Moreover, cost-effectiveness considerations are largely absent, limiting the practical applicability and policy relevance of these approaches. Addressing these gaps is essential for the successful integration of technology-based spinal health education in school settings.

Sixth, many teachers do not feel competent to teach health-related content. They often lack both subject-specific and pedagogical knowledge required for health education. There is a clear need for comprehensive pre-service and in-service training programs for teachers to better support student health.[43]

Seventh, interdisciplinary and collaborative models remain underexplored. Programs involving multiple stakeholders, teachers, school nurses, parents, physiotherapists, and even university students through service learning, represent promising strategies for sustainable implementation.[48] Research should also examine effective methods for training teachers or peer leaders to deliver such programs autonomously over time.

Finally, most studies have focused on knowledge outcomes, while pain and functional metrics remain underreported. Future research should incorporate clinically relevant endpoints such as pain frequency, intensity, physical function, school absenteeism, and quality of life. Measuring these long-term outcomes will be critical to evaluating the actual impact and cost-effectiveness of school-based spinal health interventions.

Practical Applications

In light of these identified gaps, there is a critical need for comprehensive and methodologically robust evaluations of school-based spinal health programs. Policymakers and researchers should prioritize the development and assessment of evidence-based, scalable interventions that are both pedagogically sound and clinically relevant. In the interim, educators may consider integrating foundational concepts of spinal health into existing health or physical education curricula, as such inclusion carries minimal risk and offers potential benefit. Additionally, the implementation of basic ergonomic measures —such as the use of adjustable desks, education on proper backpack loading, and the incorporation of regular movement breaks —may contribute to the creation of a more supportive musculoskeletal environment within schools.

Conclusions

School-based educational interventions show considerable promise in improving spinal health awareness and promoting healthy postural habits among children and adolescents. Interventions that combine physical activity with interactive, student-centered learning components tend to yield more favorable outcomes. Globally, the implementation of such programs remains inconsistent, often dependent on the initiative of individual educators or health professionals. To advance the field, future research must adopt more rigorous, innovative, and longitudinal approaches. Given the high and growing prevalence of spinal pain in youth populations, integrating posture and musculoskeletal health education into routine school health promotion —particularly through the use of digital technologies and interdisciplinary collaboration —represents a valuable public health strategy.

Ethical Committee approval

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The authors have no conflicts of interest to declare.

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Author-s contribution

Conceptualization, M.P. and M.K.L.; methodology, M.P; software, P.W.; validation, M.K.L. and P.W.; formal analysis, M.P.; investigation, M.P.; resources, P.W.; data curation, M.P.; M.K.L. and P.W.; writing—original draft preparation, M.P.; M.K.L. and P.W.; writing— review and editing, M.P.; M.K.L.

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