

Relationship between school furniture design and musculoskeletal problems in children: an ergonomic approach

Relación entre diseño del mobiliario escolar y problemas musculoesqueléticos en niños: un enfoque ergonómico

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ABSTRACT

Introduction: ergonomics of school furniture is a priority issue, since mismatches between desks and children's anthropometric diversity generate forced postures, discomfort and musculoskeletal problems that affect health and performance. In Peru, where obsolete furniture persists, the situation exposes to preventable risks and requires rethinking educational design from an ergonomic approach.

Objective: to describe the relationship between school furniture design and musculoskeletal problems in primary school children, from an ergonomic approach, with special reference to the context of Banda de Shilcayo, Peru.

Method: this literature review was developed using a qualitative approach of documentary analysis, compiling studies and official documents on school furniture, ergonomics and children's musculoskeletal problems, based on searches in databases such as PubMed, Scopus, Web of Science, SciELO and Google Scholar.

Development: school furniture has moved from rigid and collective benches to designs that incorporate ergonomic criteria and international standards. However, mismatches persist between the dimensions of the furniture and children's anthropometry, which generates problems with progressive consequences: in the short term they cause discomfort and distraction, in the medium term they generate chronic postural alterations, and in the long term they predispose to lumbago, hernias and scoliosis. Studies in several countries report high rates of mismatch and its association with back pain and risk of spinal deformities.

Conclusions: incorrectly designed dimensions of school furniture have significant effects on the musculoskeletal health of schoolchildren; they generate immediate discomfort, postural alterations and health risks if not corrected.

Keywords: Ergometry; School Furniture; Musculoskeletal; Health Problems; Child Anthropometry.

RESUMEN

Introducción: la ergonomía del mobiliario escolar es un tema prioritario, pues los desajustes entre pupitres y la diversidad antropométrica infantil generan posturas forzadas, incomodidad y problemas musculoesqueléticos que afectan salud y rendimiento. En Perú, donde persiste mobiliario obsoleto, la situación expone a riesgos prevenibles y exige repensar el diseño educativo desde un enfoque ergonómico.

Objetivo: describir la relación entre el diseño del mobiliario escolar y los problemas musculoesqueléticos en niños de nivel primario, desde un enfoque ergonómico, con especial referencia al contexto de Banda de Shilcayo, Perú.

Método: esta revisión bibliográfica se desarrolló mediante un enfoque cualitativo de análisis documental, recopilando estudios y documentos oficiales sobre mobiliario escolar, ergonomía y problemas musculoesqueléticos infantiles, a partir de búsquedas en bases como PubMed, Scopus, Web of Science, SciELO y Google Scholar.

Desarrollo: el mobiliario escolar ha transitado de bancos rígidos y colectivos a diseños que incorporan criterios ergonómicos y normas internacionales. Sin embargo, persisten desajustes entre las dimensiones del mobiliario y la antropometría infantil, lo que genera problemas con consecuencias progresivas: a corto plazo causan molestias y distracción, a mediano generan alteraciones posturales crónicas, y a largo plazo predisponen a lumbalgias, hernias y escoliosis. Estudios en varios países reportan altas tasas de mismatch y su asociación con dolor de espalda y riesgo de deformidades espinales.

Conclusiones: las dimensiones incorrectamente diseñadas del mobiliario escolar tienen efectos significativos sobre la salud musculoesquelética de los escolares; generan molestias inmediatas, alteraciones posturales y riesgos de salud si no se corrigen.

Palabras clave: Ergometría; Mobiliario Escolar; Musculoesquelético; Problemas de Salud; Antropometría Infantil.

INTRODUCTION

In recent years, ergonomics applied to basic education has become increasingly important, especially in relation to the design of school furniture. In many countries, furniture continues to be manufactured with standardized measurements that do not always take into account the diversity of students' bodies. This lack of adaptation often leads to poor posture, discomfort, and, over time, the onset of musculoskeletal disorders that affect both the well-being and academic performance of children.⁽¹⁾

Musculoskeletal disorders in childhood have been documented in different contexts around the world. In Europe, for example, a study conducted in Poland in 2021 showed that more than half of schoolchildren (around 55 %) suffered from back and neck pain due to the mismatch between furniture and their body dimensions.⁽²⁾ Similarly, in Turkey, a 2022 study found that in seven out of ten cases, the height of desks did not match the height of students, resulting in a high number of muscular complaints.⁽³⁾ These results reinforce the idea that school ergonomics is not a minor issue, but a real challenge for public health.

In Latin America, the findings are no more encouraging. In Brazil, a 2021 study found that 72 % of primary school children experienced lower back, shoulder, or neck pain at the end of the school day, identifying furniture as one of the main factors.⁽⁴⁾ In Mexico, a 2020 study reported that almost half of schoolchildren (49 %) mentioned lower back discomfort related to inadequate desks in urban classrooms.⁽⁵⁾ In Colombia, recent ergonomic assessments indicated that more than 65 % of public school furniture does not fit students' body measurements, affecting their concentration and learning.⁽⁶⁾

In Peru, the situation is particularly relevant. A study conducted in Lima in 2019 revealed that more than 40 % of desks in public schools did not correspond to the dimensions of the students, causing forced postures and frequent discomfort.⁽⁷⁾ In rural areas, such as Ayacucho, the problem is exacerbated: the reuse of old furniture, designed to standards that no longer correspond to the average size of today's children, contributes to even more common poor posture.⁽⁸⁾ More recently, a 2023 regional report in San Martín warned that much of the school furniture still does not meet basic ergonomic criteria, directly affecting students' comfort and academic performance.⁽⁹⁾

In places such as Banda de Shilcayo, in the San Martín region, this reality is repeated. Many educational institutions still use old desks that do not meet the physical needs of today's schoolchildren. This lack of suitability results in discomfort, distraction during classes and, in the long term, the onset of musculoskeletal disorders that could be prevented with appropriate furniture.^(9,10)

Interest in studying this issue is not limited to the physical realm. Incorrect posture maintained from an early age not only affects the spine and joints, but also predisposes children to chronic ailments in adulthood, such as low back pain or scoliosis.⁽¹¹⁾ In addition, physical discomfort can reduce children's concentration, academic performance, and motivation, making furniture design an essential component of educational quality.⁽¹²⁾

Despite international and regional evidence, many Peruvian schools still do not have furniture that meets adequate ergonomic and anthropometric parameters. In the case of Banda de Shilcayo, most primary school students use desks that do not fit their height or body proportions. This raises the central question: what is the relationship between school furniture design and the onset of musculoskeletal problems in primary school children from an ergonomic perspective?

General objective: to describe the relationship between the design of school furniture and musculoskeletal problems in primary school children from an ergonomic perspective, with special reference to the context of Banda de Shilcayo, Peru.

METHOD

This literature review was conducted using a qualitative approach to document analysis. Original articles, systematic reviews, book chapters, and official documents addressing the relationship between school furniture design, ergonomics, and the onset of musculoskeletal problems in children were collected.

Search strategy

Searches were conducted in international databases such as PubMed, Scopus, Web of Science, SciELO, and Google Scholar, using the keywords: "school furniture," "ergonomics," "musculoskeletal disorders," "children," "anthropometry," "classroom design," and their equivalents in Spanish ("school furniture," "ergonomics," "anthropometry," "ergonomics," "musculoskeletal disorders," "children," "anthropometry").

Inclusion criteria

- Studies published between 1995 and 2024 (with preference for those from the last 5 years).
- Research involving children (aged 6–12), although some studies involving adolescents were also included for comparative reference.
- Studies that directly related school furniture design to musculoskeletal health indicators or ergonomic parameters.
- Official documents and technical guidelines from international organizations (WHO, ILO, UN, ministries of education).

Exclusion criteria

- Studies that addressed school furniture only from an architectural or aesthetic perspective, without relation to

ergonomics.

- Documents without access to the full text or without verifiable references.

Selection process

From a total of approximately 150 initial documents, 42 were selected for meeting the inclusion criteria. Subsequently, after critical reading, these were reduced to 22 main references that form the basis of this review, ensuring international, regional, and national representativeness.

Analysis procedure

The information was organized into thematic matrices considering:

1. International, regional, and local context.
2. Prevalence of musculoskeletal problems in schoolchildren.
3. Relationship between anthropometry and furniture design.
4. Ergonomic interventions and their results.

DEVELOPMENT

Historical evolution of school furniture and transformations in favor of health

School furniture, as we know it today, was not always designed with ergonomic criteria in mind. During the 19th and early 20th centuries, desks were usually long wooden benches, without individual backrests and shared by several students. They were rigid pieces of furniture, with no possibility of adjustment, made from simple materials such as wood and wrought iron. At that time, comfort, posture, or the prevention of ailments were not priorities; the focus was on durability and low cost.^(13,14)

Over time, as pedagogy and children's health became more important, improvements began to be introduced. Individual desks, chairs with backrests, lighter materials, and designs that sought to better adapt to the physical characteristics of students appeared. In Europe, for example, European Standard 1729 established anthropometric criteria for the manufacture of school furniture, considering child population percentiles (P5–P95) to define the appropriate heights for seats, backrests, and desks.⁽¹⁵⁾

In recent years, research on school ergonomics has continued to advance. One example is the study “Post-COVID-19 ergonomic school furniture design under fuzzy logic” (2022), in which static anthropometric dimensions of primary school students were measured and furniture designs based on that data were proposed. This type of study not only incorporates ergonomic criteria focused on health and well-being, but also on the new demands that have arisen in the wake of the pandemic. Thus, the current trend is toward furniture adapted to the actual population rather than generic standards inherited from the past.⁽¹⁶⁾

According to the authors of this review, this evolution reflects a progressive recognition of the problem. Initially, improvements focused on the most obvious aspects, such as seats and backrests; later, attention turned to measurable aspects, such as anthropometric dimensions. Today, the goal is more ambitious: to create flexible, adjustable furniture that promotes dynamic postures that accompany the natural movement of children's bodies.

Effects of poorly adjusted furniture on musculoskeletal health

When school furniture does not fit students' body dimensions, various adverse effects begin to appear that can affect both their comfort and their long-term health. The main mechanisms and types of misalignments that cause these discomforts are described below.^(10,17,18,19)

- Forced and sustained postures: if the seat height is too high in relation to the popliteal height, the feet do not reach the floor; if it is too low, the knees are raised excessively. In both cases, tension is generated in the thighs and hips.
- Excessive flexion of the neck and shoulders: very high desks force the shoulders to be raised when writing, while low desks force the trunk and neck to be tilted forward, increasing pressure on the cervical spine and intervertebral discs.
- Pressure on thighs and buttocks: Seats that are too deep compress the back of the knees or prevent proper lumbar support, which promotes numbness, poor circulation, and discomfort in the lower back.
- Limited movement and muscle fatigue: staying in the same position for a long time, without the possibility of moving or changing position, causes the stabilizing muscles to work continuously, generating fatigue and accumulated tiredness.

Types of poorly adjusted dimensions and examples^(17,18,19)

Some specific dimensions that have been consistently identified as poorly adjusted:

An illustrative example is the study conducted in Turkey in 2021, which found that more than 95 % of desks and chairs had a mismatch between seat depth and buttock-popliteal length (seat-depth/buttock-popliteal length mismatch). In simple terms, this means that the seat depth was too large or too small in relation to the students' legs, which encouraged poor posture and strain on the back of the legs and lower back.⁽²⁰⁾

Something similar was identified in Nigeria in 2023, in the study “Mismatch between school furniture dimensions and anthropometric parameters is a risk for spinal deformities.” There, it was found that 59,1 % of students had mismatches between seat width and hip width, which could contribute to the development of mild spinal deformities and recurrent back pain.⁽²¹⁾

Table 1. Dimensions identified as poorly adjusted

Dimension	Common type of poor fit	Most frequent consequences
Seat height	Seats that are too high or too low in relation to the popliteal height	Tension in thighs, pressure on back, lack of foot support (causing instability)
Seat depth	Seat too deep or too short in relation to the length of the buttocks and popliteal fossa	Poor lumbar posture, loss of back support, numbness
Desk height	desk too high in relation to elbow level; or too low	raised shoulders, neck tilt, kyphotic posture of the upper trunk
Backrest	backrest too low to support the lumbar region or no backrest	lumbar tension, hyperlordosis, or compensatory kyphosis
Seat-desk space	lack of leg clearance; limited foot space	discomfort, pressure on legs, crossed postures causing asymmetries

Short-, medium-, and long-term consequences

The effects of inadequate furniture can manifest at different times and with varying intensity:

- In the short term (days or weeks): muscle discomfort, fatigue, numbness in the legs or arms, neck or back pain at the end of the school day, and difficulty concentrating in class.
- Medium term (months or one to two years): intermittent chronic pain, visible postural changes—such as lateral tilts, kyphosis, or small humps—decreased physical capacity, muscle spasms, and sleep disorders caused by persistent pain may appear.
- In the long term (several years or adulthood): the risk extends to degenerative diseases of the spine, chronic low back pain, herniated discs, or progressive scoliosis. In addition, quality of life is reduced, limitations on physical activity arise, and the demand for medical care increases. Psychological consequences may even arise, such as stress or anxiety resulting from constant pain, with a direct impact on productivity and overall well-being.

The author of this review considers that many of these effects are not only predictable but also already evident in various school settings, especially those with limited resources, where ergonomic interventions are often delayed, partial, or non-existent.

Recent evidence from interventions and quantitative studies

In recent years, various studies have attempted not only to describe the magnitude of the problem, but also to quantify the risk and propose concrete solutions.

The study “Post-COVID-19 ergonomic school furniture design under fuzzy logic” (2022) analyzed the anthropometric dimensions of 2 049 students between the ages of 7 and 10. The results confirmed that most school furniture does not fit the actual measurements of children. Based on this data, the authors developed new designs based on percentiles, demonstrating that by considering variables such as age, gender, and actual body measurements, it is possible to significantly reduce ergonomic risks through the use of adjustable furniture.⁽¹⁶⁾

In Turkey, the study “Comparison of classroom furniture to anthropometric measures of Turkish middle school students” reported an average mismatch of 66,6 % between furniture dimensions and student measurements. The most pronounced mismatches were found in seat depth and seat-to-desk clearance.⁽²⁰⁾

In Saudi Arabia, a study in middle and high schools found that 84,3 % of chairs were of inadequate height, and 94,1 % of desks were of incorrect height. Both factors were significantly associated with back pain during prolonged periods of sitting.⁽²¹⁾

In Nigeria, in addition to mild spinal deformities, it was observed that uncorrected mismatches also caused joint problems, with seat width and depth being the factors most strongly correlated with pain.⁽²²⁾

Finally, a study conducted in the United States—“Does ergonomic mismatch at school impact pain in school children?”—with a sample of 139 students confirmed a high prevalence of ergonomic mismatches. Although the statistical relationship with pain was complex, the researchers noted that the groups with the greatest errors in desk height and body posture reported more physical discomfort.⁽²³⁾

Opinion of the authors of this review

In the authors’ opinion, although the studies reviewed make it clear that there is a direct relationship between inadequate furniture and musculoskeletal problems in students, significant gaps remain. There is a lack of long-term follow-up research to observe how these effects evolve over the years, as well as studies that measure the real impact of specific interventions, for example, when furniture is replaced and students’ postural health is monitored.

In addition, many of the projects to redesign desks and chairs remain theoretical or experimental, without being effectively incorporated into educational policies or institutional budgets. This disconnect between scientific evidence and school practice limits the scope of the progress made so far.

Design recommendations: ideal dimensions, adjustments, and corrective strategies

Based on an analysis of the most recent literature and the author’s reflections, the following practical guidelines are proposed to

improve the design of school furniture and reduce ergonomic risks:

1. Use of broad percentiles: Furniture design should not be based solely on average measurements (50th percentile), but should consider a broader range—for example, from the 3rd to the 75th percentile—that reflects the diversity of students' heights and body proportions. This includes parameters such as popliteal height, buttock-popliteal length, and seated elbow height.
2. Adjustable furniture: It is recommended to use chairs and tables with mechanisms for adjusting height, backrest, and, if possible, seat depth. Adaptability allows the same piece of furniture to serve students of different ages or sizes.
3. Ergonomic design and materials: the backrest should provide lumbar support, the seat surface should allow ventilation, and the edges should be rounded to avoid pressure on the legs. It is also important to ensure sufficient legroom and that the feet can rest firmly on the floor or on a footrest.
4. Postural variability and active breaks: It is essential to encourage students to change their posture frequently. Short breaks to stretch or walk around help reduce muscle tension and improve concentration. Some types of “dynamic” furniture—such as tilting tables or tables with movable surfaces—can promote this variability.
5. Training and proper use: Just as important as furniture design is ensuring that teachers and students know how to use it correctly. Adjusting chairs, maintaining healthy posture, and recognizing signs of fatigue should be part of posture education in schools.
6. Updated national regulations: It is recommended that ministries of education develop or update their ergonomic standards based on recent local anthropometric studies. These standards should be mandatory for all furniture used in public and private institutions.
7. Regular assessments and active participation: regularly measuring students' body dimensions allows furniture to be adapted to their growth changes. In addition, involving students and teachers themselves in the design process ensures that the final products are truly functional and comfortable in everyday use.

CONCLUSIONS

Incorrectly designed school furniture has a significant impact on the musculoskeletal health of schoolchildren, causing immediate discomfort, postural problems, and health risks if not corrected.

Problems manifest quickly after prolonged use of inadequate furniture (within days or weeks), worsen in the medium term with adaptive postures and contractures, and in the long term can lead to chronic conditions such as scoliosis, affected intervertebral discs, persistent pain, and reduced quality of life.

Recent studies using local anthropometric measurements, broad percentiles, and adjustable furniture design show that it is possible to mitigate these risks considerably; however, these corrective measures need to be integrated into educational policies, school budgets, and classroom practices.

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CONFLICTS OF INTEREST

No conflicts of interest declared.

AUTHOR CONTRIBUTION

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