



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 acquired increasing importance, especially in relation to the design of school furniture. In many countries, furniture continues to be manufactured with standardized measurements that do not always consider the body diversity of students. This lack of adaptation often causes inadequate postures, discomfort and, over time, the appearance of musculoskeletal disorders that affect both the well-being and academic performance of boys and girls.(1)

Musculoskeletal alterations in childhood have been documented in different contexts around the world. In Europe, for example, one study conducted in Poland in 2021 showed that more than half of schoolchildren (around 55 %) suffered from back and neck pain due to the lack of correspondence between furniture and their body dimensions.(2) Similarly, in Turkey, a 2022 investigation revealed that in 7 out of 10 cases the height of the desks did not match the students' height, which resulted in a high number of muscle discomfort.(3) These results reinforce the idea that school ergonomics is not a minor issue, but rather a real challenge for public health.

In Latin America, the findings are not more encouraging. In Brazil, a 2021 study indicated that 72 % of elementary school children experienced low 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 investigation reported that almost half of schoolchildren (49 %) mentioned lumbar discomfort related to inadequate desks in urban classrooms (5). In Colombia, recent ergonomic evaluations indicated that more than 65 % of public school furniture does not adjust to the body measurements of students, affecting their concentration and learning (6).

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

In localities such as Banda de Shilcayo, in the San Martín region, this reality is repeated. In many educational institutions, old desks are still used that do not meet the physical needs of today's schoolchildren. This lack of adaptation is reflected in discomfort, distraction during classes, and, in the long term, in the appearance of musculoskeletal disorders that could be prevented with appropriate furniture (9,10).

The interest in studying this problem is not limited to the physical realm. Incorrect postures maintained from an early age not only affect the spine and joints, but also predispose to chronic ailments in adulthood, such as lower back pain or scoliosis.(11) Furthermore, bodily discomfort can decrease 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, a large proportion of primary school students use desks that are not adjusted to their height or body proportions. Hence the central question arises: what relationship exists between the design of school furniture and the appearance of musculoskeletal problems in primary school children from an ergonomic approach?

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

METHODS

The present bibliographic review was developed following a qualitative approach of documentary analysis. Original articles, systematic reviews, book chapters, and official documents that addressed the relationship between the design of school furniture, ergonomics, and the appearance of musculoskeletal problems in the child population were collected.

Search strategy

Searches were conducted in international databases such as PubMed, Scopus, Web of Scien-

ce, SciELO and Google Scholar, using the keywords: “school furniture”, “ergonomics”, “musculoskeletal disorders”, “children”, “anthropometry”, “classroom design” and their Spanish equivalents (“mobiliario escolar”, “ergonomía”, “trastornos musculoesqueléticos”, “niños”, “antropometría”).

Inclusion Criteria

Studies published between 1995 and 2024 (with preference for the last 5 years).

Research with child populations (6–12 years), although some adolescents were also included as a comparative reference.

Studies that directly related the design of school furniture with musculoskeletal health indicators or ergonomic parameters.

Official documents and technical guides from international organizations (OMS, OIT, ONU, ministries of education).

Exclusion criteria

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

Documents without full-text access or without verifiable references.

Selection process

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

Analysis Procedure

The information was organized into thematic matrices considering:

International, regional, and local context.

Prevalence of musculoskeletal problems in schoolchildren.

Relationship between anthropometry and furniture design.

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 conceived with ergonomic criteria. During the nineteenth and early twentieth 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; what was sought was durability and low cost.^(13,14)

Over time, as pedagogy and child health gained relevance, improvements began to be introduced. Individual desks, chairs with backrests, lighter materials, and designs aimed at better adapting to the physical characteristics of students appeared. In Europe, for example, the European Standard 1729 established anthropometric criteria for the manufacture of school furniture, considering percentiles of the child population (P5–P95) to define appropriate heights for seats, backrests, and desks.⁽¹⁵⁾

In recent years, research on school ergonomics has continued to advance. An 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 these data were proposed. This type of studies not only incorporates ergonomic criteria focused on health and well-being, but also on the new demands arising after the pandemic. Thus, the current trend points toward furniture adapted to the real population and not to generic standards inherited from the past.⁽¹⁶⁾

This evolution reflects, according to the authors of the present review, a progressive recognition of the problem. Initially, improvements focused on the most evident aspects, such as seats or backrests; subsequently, 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 the child's body.

Effects of poorly adjusted furniture on musculoskeletal health

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

Forced and maintained postures: if the seat height is too high relative to the popliteal height, the feet do not reach the floor; if it is too low, the knees are raised excessively. In both cases, tensions are generated in the thighs and hips.

Excessive flexion of the neck and shoulders: very high tables force the shoulders to be raised when writing, while low tables force the trunk and neck to lean 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 area.

Limited movement and muscle fatigue: remaining in the same posture for a long time, without the possibility of moving or changing position, causes the stabilizer 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 fitted:

Table 1. Dimensions identified as misfitting

Dimension	Common type of misfit	Most frequent consequences
Seat height	seat too high or too low relative to popliteal height	tension in thighs, rear pressure, and lack of foot support (cause of instability)
Seat depth	seat too deep or too short relative to buttock-popliteal length	poor lumbar posture, loss of back support, and numbness
Desk / school desk height	desk too high relative to elbow level, or too low	elevated shoulders, neck tilt, and kyphotic posture of the upper trunk
Support	backrest too low to support the lumbar region, or absence of a backrest	lumbar tension, hyperlordosis, or compensatory kyphosis
Seat-desk space	lack of clearance for legs; limited space for feet	discomfort, pressure in legs, and crossed postures that cause asymmetries

An illustrative example is the study conducted in Turkey in 2021, where it was observed that more than 95 % of desks and chairs presented a disproportion 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 favored inappropriate postures and an overload on the back of the legs and the lumbar area.(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 breadth, which could contribute to the development of mild spinal deformities and recurrent back pain.(21)

Short-, medium-, and long-term consequences

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

Short-term (days or weeks): muscle discomfort, a feeling of fatigue, numbness in the legs or arms, neck or back pain at the end of the school day, and difficulty maintaining concentration in class.

In the medium term (months or a year or two), chronic intermittent pain, visible postural alterations (such as lateral tilts, kyphosis, or small humps), decreased physical capacity, muscle contractures, and sleep disorders caused by persistent pain may appear.

In the long term (several years or in 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 appear in performing physical activities, and the demand for medical care increases. Even psychological consequences may arise, such as stress or anxiety resulting from constant pain, with a direct impact on productivity and general well-being.

The author of this review considers that many of these effects are not only foreseeable, but also already evident in various school settings, especially in those with limited resources, where

ergonomic interventions are often late, partial, or nonexistent.

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 aged between 7 and 10 years. The results confirmed that most school furniture does not fit the actual measurements of children. Based on these data, the authors developed new designs based on percentiles, demonstrating that by considering variables such as age, sex, and real 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 the furniture dimensions and the students’ measurements. The most pronounced mismatches occurred in the seat depth and in the space between seat and desk (seat-to-desk clearance) (20).

In Saudi Arabia, one study in intermediate and secondary schools identified that 84,3 % of chairs had an inadequate height, and 94,1 % of desks had an incorrect desktop 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 misalignments also caused joint problems, with seat width and depth being the factors most correlated with pain.(22)

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

Opinion of the authors of the present review

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

Furthermore, many desk and chair redesign projects remain at the theoretical or experimental stage, without being effectively integrated into educational policies or institutional budgets. This disconnect between scientific evidence and school practice limits the scope of the advances achieved to date.

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 school furniture design and reduce ergonomic risks:

Use of broad percentiles: furniture design should not be based solely on average measurements (50th percentile), but rather consider a broader range—for example, from the 3rd to the 75th percentile—reflecting the diversity of student heights and body proportions. This includes parameters such as popliteal height, buttock-popliteal length, or sitting elbow height.

Adjustable furniture: it is recommended to use chairs and tables with adjustment mechanisms for height, backrest, and, if possible, seat depth. This adaptability allows the same piece of furniture to serve students of different ages or sizes.

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 to allow the feet to rest firmly on the floor or on a footrest.

Postural variability and active breaks: encouraging students to change posture frequently is essential. Short breaks to stretch or walk help reduce muscle tension and improve concentration. Some types of dynamic furniture—such as adjustable tables or those with movable surfaces—may promote this variability.

Training and proper use: as important as the design of the furniture is that teachers and students know how to use it correctly. Adjusting the chair, maintaining a healthy posture, and recognizing signs of fatigue should be part of postural education in school.

Updated national regulations: it is recommended that ministries of education develop or update their ergonomic standards based on recent local anthropometric studies. These standards must be mandatory for all furniture used in public and private institutions.

Periodic evaluations and active participation: regularly measuring students' body dimensions allows furniture to be adapted to their growth changes. Furthermore, involving students and teachers in the design process ensures that the final products are functional and comfortable in daily practice.

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.

The problems manifest rapidly 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 employing local anthropometric measurements, the use of broad percentiles, and adjustable furniture design show that it is possible to mitigate these risks considerably; however, these corrective measures must be integrated into educational policies, school budgets, and classroom practices.

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24. CONFLICTOS DE INTERESES

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CONFLICT OF INTEREST

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