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Investigating the Impact of Furniture on Posture and Discomfort Levels among Primary and Secondary Students

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Abstract: *Comprehensive anthropometric data was collected from primary and secondary sections of eight schools. This inclusive approach ensured a broad spectrum of experiences and conditions related to school furniture and student comfort, thereby facilitating a nuanced understanding of ergonomic challenges across diverse educational settings. Employing rigorous comparison analytic methodologies, the research juxtaposed the anthropometric dimensions of children with the furniture dimensions provided by schools. The primary objective of this research is to ascertain how inadequate furniture design contributes to poor posture among primary and secondary students, potentially impacting their long-term health and academic performance. Through thorough analysis, the study aims to identify and quantify variations in student physical characteristics and furniture design specifications, with a particular focus on factors such as seat height, depth, width, and desk height. Central to the investigation is the utilization of the Visual Analog Scale (VAS) to assess pain levels resulting from prolonged sitting. By leveraging the VAS, the study seeks to comprehend the impact of ergonomic disparities on students' daily experiences and overall well-being. Insights derived serve as a foundation for proposing legislative reforms and initiatives that prioritize children's physical well-being within educational environments. The integration of data collection, comparison analysis, and VAS assessments enables the study to provide actionable insights for enhancing the ergonomic quality of classroom furniture. Findings contribute to the development of learning environments that prioritize students' physical well-being, ultimately fostering conditions conducive to academic success and long-term health. Recommendations include considering dimensions such as popliteal height, sitting height, and shoulder breadth based on percentiles, thus accommodating diverse physical characteristics of the student population. This holistic approach aims not only to address immediate discomfort but also to promote sustained physical well-being and academic performance among students.*

Key Words: *Visual Analog System (VAS), Awkward posture, Furniture misfit, anthropometry, Musculoskeletal discomfort.*

1. INTRODUCTION :

Understanding the role of furniture design in influencing the posture and comfort of primary and secondary students is essential. Inadequate furniture can contribute significantly to poor posture, which may impact students' long-term health and academic performance. This study aims to explore these challenges and suggest ways to set up school spaces for better comfort and productivity.

Anthropometry, the study of human body measurements and proportions, is crucial in designing products and spaces that fit people comfortably and efficiently. Applying anthropometric principles to furniture design can address the issues of poorly designed school furniture by ensuring a better fit for students' bodies. This approach promotes proper posture, reduces discomfort, and enhances productivity, particularly in computer labs (Pheasant, 2018). Ergonomically

constructed furniture is vital for creating conducive learning environments, especially in settings where technology and prolonged sitting are prevalent (Rao, 2018).

A comprehensive study was conducted to examine the impact of non-ergonomic furnishings on student well-being across several schools in Mumbai, its suburbs, and the Thane area. The study aimed to assess how current furniture designs affect students' posture and discomfort levels, providing valuable insights into the need for ergonomic improvements.

By analyzing anthropometric data and comparing it with the dimensions of existing school furniture, the study seeks to identify mismatches and propose solutions. The goal is to advocate for the design and implementation of furniture that supports students' physical health and academic success. This research underscores the importance of ergonomically sound furniture in educational settings and its potential to foster a more comfortable and productive learning environment for students.

In the rapidly evolving educational landscape, the comfort and well-being of students, especially in computer labs, have become paramount. Despite the significant strides in educational ergonomics globally, Mumbai — a city grappling with severe space constraints —has seen limited research in this critical area. This study aims to bridge that gap by evaluating the anthropometric data of primary and secondary students and aligning it with the dimensions of school computer lab furniture to achieve a "perfect fit."

Existing studies underscore the urgent need for ergonomic interventions in educational settings. (Elizabeth Chacko, 2018), demonstrated that a multidisciplinary approach to managing low back pain in computer users is more effective than conventional methods. Their study, conducted among BBA students in Bangalore, highlighted the prevalence of discomfort due to poor ergonomic practices, suggesting that healthy work habits, regular health checkups, and ergonomic training can significantly mitigate these issues. Similarly, research at Punjab Agricultural University found that poor ergonomic practices among students led to high incidences of musculoskeletal disorders (MSDs). Their study revealed that most students lacked awareness of proper ergonomic practices, with a significant percentage experiencing neck, back, and lower limb pain due to improper posture while using computers (Deepika Bisht, 2018). Moreover, guidelines from Pennsylvania State University emphasize the importance of ergonomic classroom furniture. Their research on first graders showed that over 50% of students experienced discomfort due to inadequate furniture, reinforcing the need for furniture designed to accommodate a wide range of body dimensions. This study's insights into anthropometric data were pivotal in recommending adjustable furniture dimensions to cater to a diverse student population (Samuel A. Oyewole, 2010).

Given the unique challenges posed by Mumbai's space constraints, this study is both timely and necessary. By systematically collecting and analyzing anthropometric data from primary and secondary students, and comparing it with existing furniture dimensions, we aim to identify mismatches and propose practical solutions (Rao D. P., 2024). This research not only addresses the immediate discomfort experienced by students but also contributes to long-term health and academic performance improvements. This study seeks to provide a robust foundation for designing ergonomic school furniture that meets the diverse needs of students in Mumbai. It emphasizes the critical role of ergonomics in educational settings, advocating for evidence-based interventions to enhance student comfort, health, and productivity.

2. SPECIFIC OBJECTIVES :

The study uses the visual analog scale to evaluate the relationship between the dimensions and design of school computer lab furniture and the postural discomfort experienced by primary and secondary students. The study seeks to identify mismatches between students' anthropometric measurements and furniture dimensions, assess the prevalence and severity of discomfort experienced by students, and propose ergonomic solutions to improve comfort, promote proper posture, and enhance the overall well-being and academic performance of students in urban school settings.

The specific objectives of the study are to (i) conduct comprehensive primary and secondary data collection to gather relevant anthropometric measurements of students, (ii) evaluate the dimensions of school computer lab furniture using the collected anthropometric data from primary and secondary sections, (iii) assess pain levels among students in both primary and secondary sections using the Visual Analog Scale (VAS), and (iv) develop and recommend strategies for adapting and designing furniture to accommodate the diverse anthropometric needs of different student groups.

3. RESEARCH METHODOLOGY :

This exploratory study employs a multifaceted approach to evaluate the impact of computer lab environments on students, incorporating various data collection methods such as a self-constructed questionnaire, personal interviews, observation, anthropometric measurements, furniture dimensions, and the Visual Analog Scale (VAS). The self-constructed questionnaire serves as a pivotal tool in gathering demographic information, computer lab-related insights, environmental factors, furniture dimensions, and anthropometric data, while the VAS provides a quantifiable measure of discomfort and aches experienced by students. Personal interviews supplement these methods, ensuring consistency through structured questionnaires or interview schedules.

Convenient and random sampling techniques were utilized to select participants for the study. Through the integration of a self-created questionnaire, personal interviews, and other instruments, the study adopts a comprehensive approach to examining the impact of computer lab environments on students. This multimodal methodology aims to gather insights into a variety of variables, encompassing demographic profiles, physical dimensions of learning environments, and students' subjective experiences as assessed by tools like the VAS.

The study sample comprised 160 students from eight schools, with each school contributing 20 participants: 10 from primary and 10 from secondary grades, evenly distributed across genders. Notably, these schools incorporated computer instruction into their curriculum, with a single computer lab catering to both primary and secondary levels. Despite the prevalence of computer instruction, a notable concern emerged regarding the absence of ergonomically designed furniture in these labs, leading to discomfort issues, particularly back and neck disorders, among students across both primary and secondary levels. This research aims to assess the extent of pain experienced by students due to the mismatch between their physical measurements and the provided furnishings.

To accurately gauge the severity of discomfort, the VAS was administered to all 160 individuals. Recognizing the challenges primary students face in articulating pain levels, the VAS serves as a reliable method for quantifying discomfort. Depicted as a straight line ranging from no discomfort to the maximum level of pain, the VAS enables students to rate the intensity of their perceived pain. Furthermore, the VAS holds the potential to assist healthcare providers in selecting optimal pain management strategies, including medication dosage.

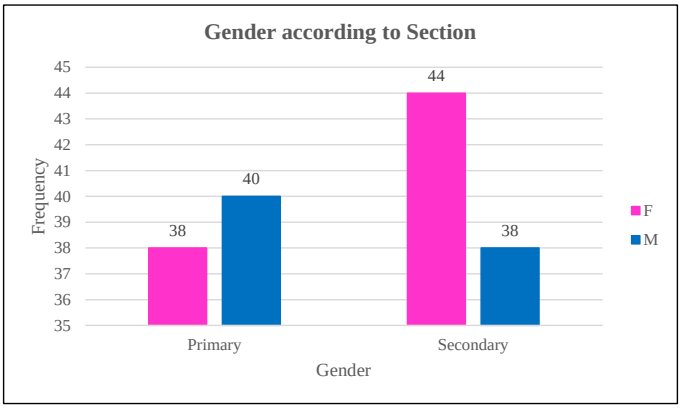
4. RESULTS :

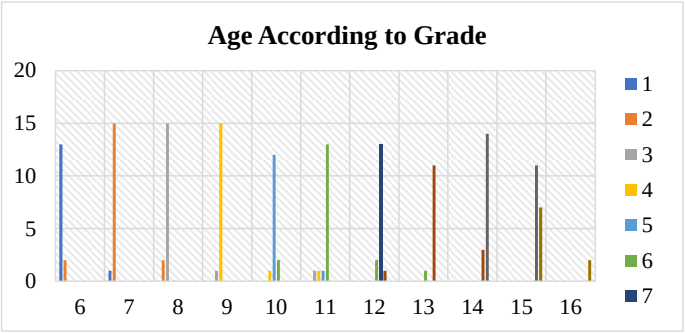
Demographic Profile: The study included a total of 160 students, with an average age of 10.2 years. Of these, 78 were boys (49%) and 82 were girls (51%). The age distribution among the participants varied, with 31(19.3%) aged 6 – 7 years, 32(20.6%) aged 8 - 9 years. Additionally, 31(19.3%) were aged 10 - 11 years, 28(17.5%) were aged 12 -13 years, 37(22.9%) were aged 14 -16 years.

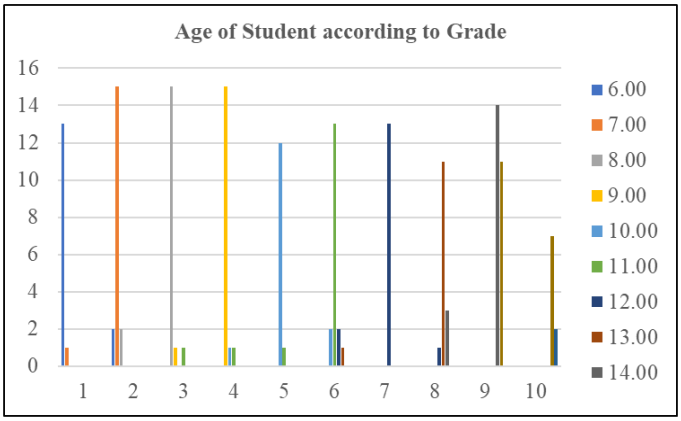
The gender distribution by age was as follows: Among 6 and 7-year-olds, there were 17 females (10.6%) and 14 males (8.6%) participated. In the 8 and 9-year-old category, there were 15 females (9.3%) and 18 males (11.2%). Among 10 and 11-year-olds, there were 15 females (9.4%) and 16 males (10.2%). For 12 and 13-year-olds, there were 17 females (10.6%) and 11 males (7%). The 14 – 16-year-olds included 18 females (11.2%) and 19 males (11.9%).

The gender distribution across the different age groups showed a relatively balanced representation, with minor variations in the number of males and females in each age category. To ensure the confidentiality of the schools involved, each school was assigned a specific code, and consent was obtained from all participating schools to keep their identities undisclosed. Throughout the study, the schools will be referred to by their code alphabets. This demographic profile provides a detailed understanding of the age and gender distribution among the students, which is essential for ensuring the representativeness and context of the study's findings.

Fig 1: Demographic Profile of the Sample







No. of participants from each School/Section

Section / School Code	Primary	Secondary	Total
School A	10	10	20 (12.5%)
School B	10	10	20 (12.5%)
School C	10	10	20 (12.5%)
School D	10	10	20 (12.5%)
School E	8	12	20 (12.5%)
School F	10	10	20 (12.5%)
School G	10	10	20 (12.5%)
School H	10	10	20 (12.5%)
Total	78	82	160 (100%)

Optimizing computer lab furniture in educational spaces is crucial for enhancing student comfort and productivity. Anthropometric measurements, represented through percentiles, provide essential insights into designing furniture that accommodates a wide range of body sizes. This study highlights the significant mismatch between existing furniture dimensions and the anthropometric measurements of primary and secondary students, underscoring the necessity for better design standards.

To ensure optimal furniture design for diverse student populations, it is essential to consider a variety of anthropometric measurements. These include shoulder breadth, upper limb length, standing height, stature, sitting height, sitting elbow height, sitting shoulder height, knee height, buttock-popliteal length, sitting eye height, thigh clearance, hip breadth, and popliteal height. For example, accommodating shoulder breadth at the 95^{th} percentile ensures sufficient spacing between chairs, which promotes inclusivity and comfort. Similarly, desks adjusted to the upper limb length at the 5^{th} percentile prevent discomfort for students with shorter arms. Providing adequate headroom for taller students, based on standing height at the 95th percentile, respects physical diversity.

Furthermore, aligning backrest or armrest height with sitting shoulder height enhances support and reduces strain. Seat depth designed according to buttock-popliteal length minimizes pressure points and discomfort during extended periods of sitting. Incorporating these anthropometric considerations into furniture design ensures an ergonomic and inclusive environment that meets the diverse needs of students.

The current disparity between furniture dimensions and students' anthropometric data highlights a critical issue: the existing furniture often fails to support proper posture and comfort, leading to potential long-term health and productivity implications. Addressing this mismatch through informed design practices is vital for fostering a conducive learning environment that promotes the well-being and academic success of all students.

Fig 2: Visual Analog Scale (VAS) (Source: https://assessment-module.yale.edu/im-palliative/visual-analogue-scale)

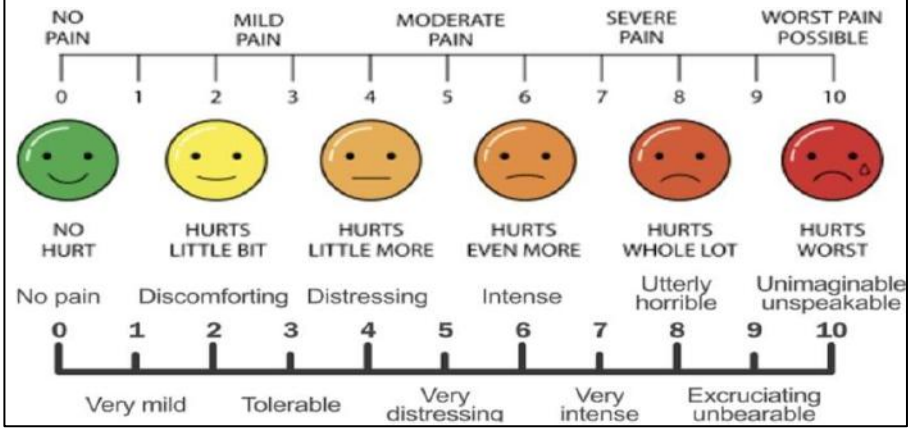
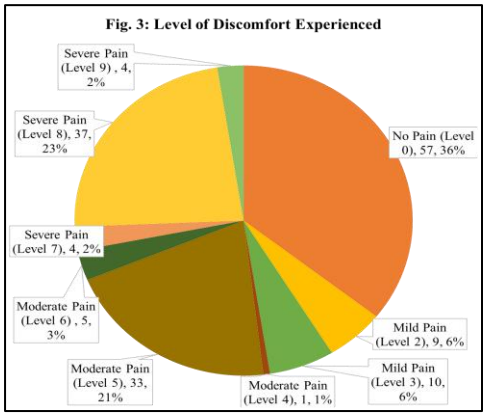


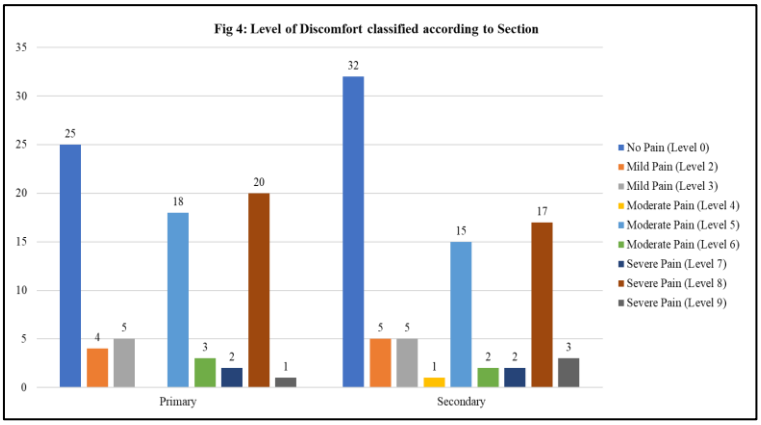
Table 1: VAS Score (Level of Discomfort Experienced) categorized School wise

VAS Score	School A		School B		School C		School D		School E		School F		School G		School H		Total	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
No Pain (Level 0)	8	40	5	25	7	35	8	40	8	40	8	40	5	25	8	40	57	35.6
Mild Pain (Level 2)	1	5	2	10	0	0	3	15	3	15	0	0	0	0	0	0	9	5.6
Mild Pain (Level 3)	0	0	3	15	1	5	3	15	2	10	0	0	0	0	1	5	10	6.2
Moderate (Level 4)	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.6
Moderate (Level 5)	1	5	4	20	7	35	4	20	3	15	2	10	5	25	7	35	33	20.6
Moderate (Level 6)	2	10	0	0	0	0	0	0	1	5	2	10	0	0	0	0	5	3.1
Severe Pain (Level 7)	0	0	0	0	1	5	0	0	1	5	0	0	1	5	1	5	4	2.5
Severe Pain (Level 8)	6	30	6	30	4	20	2	10	1	5	8	40	7	35	3	15	37	23.1
Severe Pain (Level 9)	1	5	0	0	0	0	0	0	1	5	0	0	2	10	0	0	4	2.5

Pain Index Using VAS: The results elucidate the spectrum of discomfort experienced by students, categorized into nine distinct levels, each representing escalating degrees of discomfort. The distribution reveals that most students report no pain, with 57 individuals falling under level 0. However, a notable proportion experience varying levels of discomfort, with 9 students reporting mild pain at level 2, 10 students at level 3, and 1 student at level 4, categorized as moderate pain. Further analysis indicates that 33 students experience moderate pain at level 5, while 5 students report level 6, and 4 students each report level 7, 8, and 9, indicative of severe pain. Among the surveyed cohort of 160 students, the data depicts a continuum of discomfort levels, with the highest prevalence observed at level 5, followed by severe pain levels 8 and 9.

The utilization of the Visual Analog Scale (VAS) as a pain assessment tool enables a nuanced understanding of students' pain experiences. Originally introduced in psychology by Freyd in 1923, the VAS comprises a linear continuum delineated by endpoints denoting extreme pain levels. The distance between these endpoints quantifies the intensity of pain experienced by individuals, facilitating a comprehensive assessment of discomfort levels. The VAS, also known as a Graphic Rating Scale (GRS), serves as a valuable instrument for capturing subjective pain experiences and offers insights into the multifaceted nature of discomfort among students.





The colour codes utilized in this study delineate varying levels of pain experienced by individuals, with green indicating tolerable discomfort, yellow signifying mild pain, dark yellow representing slightly heightened discomfort, dark orange indicating significant discomfort, and red denoting the most intense pain.

Employing the Visual Analog Scale (VAS), a psychometric instrument commonly employed in pain scale surveys, the study surveyed students across multiple educational institutions. The results revealed that 25 students reported pain at level 7, constituting 32% of the surveyed cohort, while 20 students reported pain at level 8, representing 26% of the total sample. Notably, students exhibited a range of pain experiences, with some reporting no discomfort, while others described varying degrees of mild, moderate, severe, or even excruciating pain. Overall, the findings underscore the heterogeneous nature of pain experiences among students, emphasizing the need for comprehensive understanding and targeted interventions.

5. DISCUSSION :

The study encompassed a total of 160 students with an average age of 10.2 years, comprising 78 boys (49%) and 82 girls (51%). The gender distribution by age revealed a relatively balanced representation, with minor variations across age categories. To maintain confidentiality, each participating school was assigned a specific code, and consent was obtained to keep their identities undisclosed.

The demographic profile highlights the necessity for optimizing computer lab furniture to enhance student comfort and productivity. This study reveals a significant mismatch between existing furniture dimensions and the anthropometric measurements of primary and secondary students, emphasizing the need for improved design standards. Anthropometric measurements, including shoulder breadth, upper limb length, standing height, sitting height, sitting elbow height, sitting shoulder height, knee height, buttock-popliteal length, sitting eye height, thigh clearance, hip breadth, and popliteal height, are crucial for designing furniture that accommodates diverse body sizes.

For instance, ensuring adequate spacing between chairs by accommodating shoulder breadth at the 95th percentile promotes inclusivity and comfort. Adjusting desks to upper limb length at the 5th percentile prevents discomfort for students with shorter arms, while providing sufficient headroom for taller students, based on standing height at the 95th percentile, respects physical diversity. Aligning backrest or armrest height with sitting shoulder height enhances support and reduces strain, and designing seat depth according to buttock-popliteal length minimizes pressure points and discomfort during prolonged sitting.

The current disparity between furniture dimensions and students' anthropometric data highlights a critical issue: existing furniture often fails to support proper posture and comfort, leading to potential long-term health and productivity implications. Addressing this mismatch through informed design practices is vital for fostering a conducive learning environment that promotes the well-being and academic success of all students.

The Visual Analog Scale (VAS) results illustrate the spectrum of discomfort experienced by students, categorized into nine distinct levels. Most students reported no pain (level 0), with 57 individuals falling under this category. However, notable proportions experienced varying levels of discomfort, with 9 students reporting mild pain at level 2, 10 students at level 3, and 1 student at level 4, categorized as moderate pain. Further analysis indicated that 33 students experienced

moderate pain at level 5, while 5 students reported level 6, and 4 students each reported levels 7, 8, and 9, indicative of severe pain. The highest prevalence of discomfort was observed at level 5, followed by severe pain levels 8 and 9.

The Visual Analog System is a method used to measure subjective experiences, such as pain levels, The VAS, a psychometric tool introduced by Freyd in 1923, comprises a linear continuum delineated by endpoints denoting extreme pain levels. The distance between these endpoints quantifies the intensity of pain experienced by individuals, facilitating a comprehensive assessment of discomfort levels. The color codes in this study delineate varying levels of pain, with green indicating tolerable discomfort, yellow signifying mild pain, dark yellow representing slightly heightened discomfort, dark orange indicating significant discomfort, and red denoting the most intense pain.

Employing the VAS, the study surveyed students across multiple educational institutions, revealing that 25 students (32%) reported pain at level 7 and 20 students (26%) reported pain at level 8. The findings underscore the heterogeneous nature of pain experiences among students, emphasizing the need for a comprehensive understanding and targeted interventions to address discomfort in educational settings.

6. SUGGESTIONS AND RECOMMENDATIONS :

Infrastructural level: These recommendations focus on physical changes made in the school environment especially provided to improve ergonomic conditions.

1. Retrofitting existing furniture with ergonomic accessories such as adjustable chairs and desks.
2. Redesigning the computer lab layouts to optimize space and comfort.
3. Installing ergonomic furniture in common areas and study spaces.

Educational level: This involves integrating ergonomic education and awareness into curriculum or educational programs. The aim is to educate students and staff about the importance of ergonomics.

1. Incorporating ergonomic awareness sessions into health education.
2. Printing instructional materials & pamphlets on proper posture and workstation ergonomics
3. Encouraging students to take breaks and engage in stretching exercises during prolonged computer use

Administrative level: These recommendations pertain to administrative decisions and actions within the school or educational institution. They focus on operational aspects that can be managed by school administrators or management.

1. Conducting regular assessments of furniture ergonomics and comfort.
2. Establishing a committee to ensure furniture procurement and maintenance.
3. Providing learning for staff and ergonomic principles and best practices.

Policy level: This involves changes at the organizational or institutional level and may issue policy formulation or amendments.

1. Introducing ergonomic standards in school furniture design.
2. Formulating guidelines for regular maintenance and replacement of furniture.
3. Allocating budget for the procurement of ergonomic furniture.

7. SCOPE OF STUDY :

The results have the potential to positively impact the community by promoting health well-being and academic success among students.

- Improve health and well-being by identifying mismatches between students' anthropometric data and school furniture dimensions, Thus can reduce MSD. Promote better posture and thereby enhance the overall physical well-being among students.
- Enhance the learning environment to reduce the risk of MSD and other health problems among young students.

8. AUTHOR STATEMENTS:

- Acknowledgments: The authors are grateful to the department for providing the opportunity to conduct this research and, to the school authorities, student participants, and their parents for their valuable input.
- Informed Consent: A written informed consent was taken from all 8 schools.
- Conflict of Interest: The authors declare that they have no conflict of interest.
- Funding: The study has not received any grants from any government or non-government funding agency.

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