Designing School Tables and Chairs based on Anthropometry of Elementary School Students in Surabaya

Perancangan Meja dan Kursi Sekolah berdasarkan Antropometri Siswa Sekolah Dasar di Surabaya

Riska Ayu Yulianingtyas, Dani Nasirul Haqi
Department of Occupational Safety and Health, Faculty of Public Health, Universitas Airlangga
Campus C Mulyorejo, Surabaya, East Java, 60115 Indonesia

ABSTRACT

Introduction: School tables and chairs are needed amongst many other facilities which support the teaching and learning activities. Uncomfortable tables and chairs can cause health problems. The purpose of this study is to design school table and chair sizes in accordance with anthropometry of elementary school students, so the tables and chairs do not cause health problems for children. **Methods:** The population used in this study was 72 students of elementary school students in Surabaya, and the sample size was 61 students. The sampling method used in this research was a simple random sampling. The anthropometric data measured were shoulder height in the sitting position, elbow height in the sitting position, popliteal-buttock length, knee height, popliteal height, shoulder width, and distance from elbow to fingertips. Meanwhile, the dimensions of tables and chairs measured were chair height, chair width, back length, back height, table height, table width, and underneath desk height. **Results:** The results of the research show that the sizes of existing tables and chairs are mismatched with student anthropometry. There are 7 dimensions of proposed table and chair sizes which are based on anthropometric data. Specifically, the chair height is 33.25 cm, chair width is 33.25 cm, backrest length is 46.50 cm, backrest height is 49.60 cm, table height is 56.85 cm, table width is 39.05 cm, and underneath desk height is 47 cm. **Conclusion:** The sizes of existing tables and chairs still need improvement in all dimensions based on the students' anthropometric measurements.

Keywords: anthropometry, chair, elementary school students, table

ABSTRAK

Pendahuluan: *Meja dan kursi sekolah diperlukan di antara banyak fasilitas yang mendukung kegiatan belajar mengajar. Meja dan kursi yang tidak nyaman dapat menyebabkan masalah kesehatan. Tujuan dari penelitian ini adalah untuk merancang ukuran meja dan kursi sekolah sesuai dengan antropometri siswa sekolah dasar sehingga meja dan kursi tidak menimbulkan masalah kesehatan bagi anak-anak.* ***Metode:*** *Populasi yang digunakan dalam penelitian ini adalah 72 siswa sekolah dasar X di Surabaya, jumlah sampel 61 siswa. Pengambilan sampel menggunakan metode simpel random sampling. Data antropometrik yang diukur adalah tinggi bahu pada posisi duduk, tinggi siku pada posisi duduk, panjang bokong-lipat lutut, tinggi lutut, tinggi lipat lutut, lebar bahu, dan jarak siku ke ujung jari. Dimensi meja dan kursi yang diukur adalah tinggi kursi, lebar kursi, panjang belakang, tinggi belakang, tinggi meja, lebar meja, dan jarak bawah meja dengan lantai.* ***Hasil:*** *Hasil penelitian menunjukkan bahwa meja dan kursi yang ada tidak cocok dengan antropometri siswa. Terdapat 7 dimensi usulan ukuran meja dan kursi dihitung dari data antropometrik siswa. Tinggi kursi 33,25 cm, lebar kursi 33,25 cm, panjang sandaran 46,50 cm, tinggi sandaran 49,6 cm, tinggi meja 56,85 cm, lebar meja 39,05 cm dan jarak bawah meja dengan lantai 47 cm.* ***Simpulan:*** *Ukuran meja dan kursi yang ada masih perlu perubahan di semua dimensi berdasarkan ukuran antropometri.*

Kata kunci: *antropometri, kursi, meja, siswa sekolah dasar*

Corresponding Author:
Dani Nasirul Haqi
Email: haqidani92@gmail.com
Telephone: +6285730396977

INTRODUCTION

School tables are facilities used for teaching and learning activities, having a flat surface and several legs. Meanwhile, school chairs are facilities for students to sit during the teaching and learning activities, having a backrest and a few legs to support

the body. The students spend more than half of the day at school (63% of their time) sitting on their seats to do their school work in a classroom (Ridgers et al., 2012). Therefore, an improper child sitting posture will interfere with the health of children (Rimes and Egg, 2004). Children's sitting posture is influenced by mismatched tables and chairs as one of the factors, so they need ergonomic tables and chairs to prevent musculoskeletal disorders in consideration that students spend large amount of time at school. It is believed that children will feel comfortable using ergonomic tables and chairs during the learning process.

Based on previous research regarding the mismatch between school tables and chairs with the anthropometry of students, it is found that the majority of mismatch is related to the dimensions of the desk height and chair height (Rosyidi et al., 2014). Another study in Chile shows that there is a need for a change in the standard size of student desks and chairs because 43% of school tables and chairs do not match the students' anthropometry, and the research shows that a new standard size of school desks and chairs could reduce mismatch rates by 82% (Castellucci and Catal, 2016). Furthermore, research conducted on students in Brazil shows that tables and chairs have an inappropriate size. The results show that 87.2% of the tables are not suitable for students and 45.6% of the chairs are not in accordance with students' anthropometry (Saes, 2015).

The use of inappropriate dimensions of tables and chairs has several detrimental effects. Research conducted on elementary school students in Iran shows that students who use non-standard tables and chairs have a higher prevalence of shoulder problems as bent shoulders, hunchback, hollow back and scoliosis compared to students who use standard tables and chairs (Zakeri et al., 2016).

In Indonesia, based on research conducted on elementary school students in Indonesia, the Indonesian standard, SNI 12-1016-1989, of chairs and tables is incompatible with students' anthropometry. Another research conducted on elementary school students in Jakarta mentioned that SNI 7555.4.2009 and SNI 7555.19.2011 show indications of discrepanciesbetween school tables and chairs used by students with students' anthropometry. Some students experience complaints resulting from the mismatch (Yanto, 2018). From the aforementioned research, it can be seen that school desks and chairs that are not ergonomic can affect children's health. The design of tables and chairs in accordance with the children's anthropometry is very necessary to support the children's health.

Based on the interviews with some of the students of an elementary school in Surabaya, the students feel uncomfortable with the tables and chairs used at school. Meanwhile, based on the observation in the same school, it is found that some students find it difficult to put their feet on the floor because the chair is too high. It can cause pain in their popliteal, and some of them even seem to change their sitting position forward to avoid the pain, but they still cannot reach the backrest. That sitting position may eventually cause back pain. Moreover, some students also find it difficult to reach the table because the table is too high. Some of them change their position to stand up when they need to write because they cannot write comfortably when sitting on their existing chair and table, and writing in a stand-up position may also cause fatigue.

During the teaching and learning process, students often change their sitting position to match their body to the existing chairs and tables. Some students look less focused while studying in the class because they have to change their sitting position frequently. Incompatible chairs and tables with students' anthropometry may cause problems in school. The purpose of this study is to propose ergonomic school tables and chairs in accordance with students' anthropometry.

METHODS

Participants and Samples

This research was conducted in one of the public elementary schools in Surabaya. The total population in this research was 72 students, and the subjects were the fifth grade elementary school students from 2 classes.

The sample size was determined using Solvin equation (Sevillaa et al., 2007), with error tolerance of 5%. The number of samples were 61 students. The research was conducted in January 2019.

Measurements of Anthropometric Chairs and Tables

A measuring tape was used to measure dimensions in this research. The measurements were taken when the subjects were seated. The dimensions measured were height of shoulder in

the sitting position, height of elbow in the sitting position, height of the popliteal, length of buttock to popliteal, knee height, width of shoulder, and the distance of the elbows to the fingertips. The dimensions of existing tables and chairs measured were the chair height, height of the backrest, table height, width of the chair, the distance between the seat with the bottom footing, and the length of the backrest and width of the table. The description of the students' anthropometric measurements are shown in Table 1 (Pheasant, 2016). Figure 1 show the picture of students' anthropometry. The detail descriptions of tables and chairs are shown in Table 2 (Salunke, 2015).

Table 1. Description of the Anthropometric Measurement

|	Dimension	Details
A	Shoulder height in the sitting position	Distance from chair's surface to the shoulder tip bone (vertically)
B	Rest height of elbow in the sitting position	Distance from chair's surface to the elbow (vertically)
C	Popliteal-buttock length	Distance from buttock's posterior surface to the popliteal angle (horizontally)
D	Knee height	Distance from the top of the knee to the floor (vertically)
E	Height of popliteal	Distance from the back of the knee to the floor (vertically)
F	Width of shoulder	Distance of the shoulder side (horizontally)
G	Distance from the elbow to the fingertips	Distance from the elbow to the fingertips (horizontally)
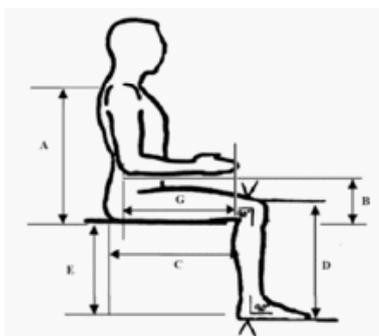
Figure 1. Students' Antropometry

Data analysis

Anthropometric data of students were then analyzed using descriptive statistics. The required values were the average, standard deviation, 5th percentile, and 95th percentile.

Proposed sizes of tables and chairs

The new table and chair sizes were obtained from students' anthropometric statistics and equation from the previous studies (Yanto, Lu and Lu, 2017). Popliteal height was used as a measure to design the chair height. The size used was 5th percentile of the popliteal height with an allowance of 2 cm. In the following formula, PH represents popliteal height in centimeter, and CH represents chair height in centimeter.

$$0.88(PH + 2) \leq CH \leq 0.95(PH + 2)$$

Shoulder height in the sitting position was used as reference to measure the backrest height of the chair. The backrest height for the proposed new chair used 0.8 of the 95th percentile of shoulder height. In the following formula, BH represents backrest height, and SH represents shoulder height in the sitting position.

$$BH \geq 80\% \ SH$$

Chair height, height of elbow, and shoulder height in the sitting position were used to design the table height. The table height was designed with 95th percentile with equation. In the following formula, TH represents table height, CH represents

Table 2. Description of the Measurement of Existing Tables and Chairs

Dimension of tables and chairs	Details
Chair height	Distance between the surface of the chair and the floor (vertically)
Chair width	Distance of the chair surface from the back to the front of the chair (horizontally)
Backrest length	Distance of the backrest from end to end (horizontally)
Height of the backrest	Distance of the backrest of the chair surface to the very top of the backrest (vertically)
Height of the table	Distance between the surface of the table and the floor (vertically)
Width of the table	Distance of one end of the table to the other end (horizontally)
Underneath desk height	Distance from the bottom of the table surface to the floor (vertically)

chair height, and SH represents shoulder height in the sitting position.

$$TH = CH + 0,8517EH + 0,1483SH$$

The distance between the popliteal and the buttocks was used to measure the chair width. The chair width was designed 0.95 from the 5th percentile distance between the popliteal and the buttocks. In the following formula, CW represents chair width and PB represents the popliteal buttock length.

$$CW \geq 95\%PB$$

Underneath desk height was designed from student knee height. The size used was 95th percentile of knee height with an allowance of 4cm. In the following formula, UD represents underneath desk height and KK represents knee height.

$$UDH \geq KH + 4$$

The backrest length was designed using shoulder width measurements. The size used was 95th percentile of shoulder width with an allowance of 0.5cm. In the following formula, BL represents backrest length and SW represents shoulder width.

$$BL \geq SW + 0.5$$

The distance from the tip of the elbow to the fingertips was used to measure the table width. The size used was the 95th percentile tip of the elbow to the tip of the finger with a clearance of 0.05cm. In the following formula, TW represents table width and EFL represents elbow to fingertiplength.

$$TW \geq EFL + 0.05$$

This study has obtained a research ethics permit from KEPK Faculty of Public Health Number 381 – KEPK Universitas Airlangga Surabaya.

RESULTS

Students' Anthropometric Data

Anthropometric data of 61 students with seven dimensions are height of shoulder in the sitting position, height of elbow in the sitting position, buttock-popliteal length, knee height, popliteal height, shoulder width, and distance from the elbow to the fingertips. The calculated statistical values in each dimension were averages, standard deviations, 5th percentile, and 95th percentile. The results of the anthropometric data are shown in Table 3.

Data of the Students' Table and Chair Sizes

The measurement data of the tables and chairs produce seven dimensions, namely chair height, chair width, backrest length, backrest height, table

height, table width, and underneath desk height. The results of the data measurement of the tables and chairs are shown in Table 4. The dimension of backrest length is the longest as it is used by two students.

Comparison Data

Anthropometric data that have been calculated were then compared to the size of existing tables and chairs. The data are a suggestion for a new table and chair size according to the children's anthropometry as shown in Table 5. Dimensions

Table 3. Students' Anthropometric Data in an Elementary School in Surabaya, January 2019

Dimension	Standard deviation	95th percentile	50th percentile	5th percentile
Height of shoulder in the sitting position	4.20	62	54.93	50
Height of elbow in the sitting position	3.51	30	24.43	19
Buttock-popliteal length	4.98	51	43.25	35
Knee height	3.30	53	47.42	43
Popliteal height	3.50	45	38.99	33
Shoulder width	3.48	46	39.84	35
Distance from the elbow to the fingertips	2.86	39	42.60	23

Table 4. Data of the Student Tables and Chairs in an Elementary School in Surabaya, January 2019

Dimension of tables and chairs	Size (cm)
Chair height	40
Chair width	39
Backrest length	100
Backrest height	42
Table height	76
Table width	37
Underneath desk height	40

of tables and chairs are chair height, chair width, backrest length, backrest height, table height, table width, and underneath desk height. The comparison of table and chair sizes is shown in Table 6.

New tables and chairs have significant size differences in several dimensions. The length dimension of the backrest has a difference of up to 53.5cm because one chair is used by 2 students. The dimension of the table height also has a difference of about 9.15cm. However, there is no big difference between the existing table width and the proposed size of table width; the difference is only about 2.05cm.

Table 5. Data of the Proposed Tables and Chairs in an Elementary School in Surabaya, January 2019

Dimension	Size	Total size
Chair height	0.95(Popliteal height + 2 cm) (5th percentile)	33.25 cm
Chair width	0.95 buttock-popliteal length (5th percentile)	33.25 cm
Backrest length	Shoulder width + 0.5 cm (95th percentile)	46.5 cm
Backrest height	0.8 shoulder height in the sitting position (95th percentile)	49.6 cm
Table height	CH + 0.8517 EH + 0.1483 SH (5th percentile)	56.85 cm
Table width	The distance from elbow to the fingertips + 0.05 cm (95th percentile)	39.05 cm
Underneath desk height	Knee height + 4 cm (5th percentile)	47 cm

Table 6. Comparison of Table and Chair Sizes in an Elementary School in Surabaya, January 2019

Dimensions of Tables and Chairs	Existing Sizes of Tables and Chairs	Proposed Sizes of Tables and Chairs
Chair height	40 cm	33.25 cm
Chair width	39 cm	33.25 cm
Backrest length	100 cm	46.5 cm
Backrest height	42 cm	49.6 cm
Table height	76 cm	56.85 cm
Table width	37 cm	39.05 cm
Underneath desk height	40 cm	47 cm

DISCUSSION

The use of tables and chairs in a long duration can affect students' health and comfort. Students who are in the growth period are better to use the tables and chairs that are suitable for their body size or anthropometry so as not to interfere with their health. Tables and chairs that are not ergonomic can pose a risk of musculoskeletal disorders (Zakeri et al., 2016). This research is conducted to design a new size of tables and chairs that is suitable for students' anthropometry, so it can reduce the risk of musculoskeletal disorders.

Chair Height

Chair height is formed using a basic anthropometry of the popliteal height. The 5th percentile of popliteal height is used for chair height. The 5th percentile is used so that students with a small or short size can still put their feet on the floor, so they can sit without feeling pain or complaints due to the pressure on the thigh or popliteal (Brewer et al., 2009). The rangeangle of 5º - 30º are used for both of the lower feet, so they can be placed on the floor, and the students can sit comfortably (Castellucci, Arezes and Molenbroek, 2014).

A research of elementary school's desks and chairs in Erbil city shows that slightly lower chair height is more comfortable for many students (Abdullah and Ahmad, 2020). In this study, a figure of 33.25cm is obtained the sum of 0.95 of the 5th percentile height of the popliteal with a clearance of 2 cm. This is in line with another previous research suggesting the use of 5th percentile of the popliteal size for the height dimension of the chair with the figure of 39.93cm (Parvez et al., 2018). Another study of students in India also shows a chair height of 399 mm, and the study uses 5th percentile of the popliteal height (Wilson and Desai, 2017).

The study of students in Nigeria also uses 2cm for the allowance of chair height (Fidelis et al., 2018). The allowance size is used for the students' shoeclearance so that they can sit comfortably without any issues. The study shows that when the seat height is too high, the feet cannot reach the floor, and the seat will press the popliteal and cause pain. Higher chair height gives students discomfort and ruins blood circulation around legs (Fidelis, Ogunlade, and Adelakun, 2020). Students are then used to leaning forward to avoid the pain and then losing their contact with backrest (Brewer et al., 2009). In addition, most students face back pain

instead of leg pain because they lose their lumbar support (Panagiotopoulou et al., 2004). A research in India found 95.8% mismatch of the old size of chair height dimension and the change of size to reduce mismatch from 95,8% to 3.66% (Parvez et al., 2018).

Chair Width

Chair width is proposed based on the dimension of the length of buttock-popliteal. The 5th percentile is used for distance from the popliteal to the buttocks. This is in line with previous research which states that the mismatched measurement of the chair width with the dimension of the knee-to-buttock length is between >95% or <80% of the popliteal-to-buttock distance (Castellucci, Arezes and Molenbroek, 2014). The chair which has more than 95% or less than 80% popliteal-to-buttock size will not be suitable to most students. Research in India shows 80% of mismatched chair width because the size is more than 100% of buttock popliteal length(Parvez et al., 2018). In this study, there is a difference between the existing chair width size and the proposed new chair width size of about 5.75 cm. This shows that the chair width is bigger than it should be.

The mismatch between chair width and buttock popliteal length leads students to have bad contact with backrest, so it causes pain in back and shoulders (Ansari, Nikpay and Varmazyar, 2018). The change of seat width size to be more ergonomic is needed due to the mismatch of chair width with popliteal-to-buttock size. When the chair width is wider than the popliteal-to-buttock size, students are unable to lean, and it will cause back pains (Castellucci and Catal, 2016).

Backrest Length

The dimension of the backrest length is formed based on the shoulder width. The width of the shoulder used is 95th percentile with an allowance of 0.05cm. The backrest length in this study is found to be 46.05 cm. This is in line with previous research which states that the backrest length is at least more than 95 percentile of the dimension of shoulder width (Pérez-gosende, 2017). Another study in Iran uses 95th percentile of the shoulder width for the backrest length proposed size (Ansari, Nikpay and Varmazyar, 2018). Moreover, research in India suggests a length of 420 mm (Wilson and Desai, 2017). Meanwhile, another research in Indonesia conducted on the design school furniture

in Yogyakarta uses 95th percentile of shoulder width to design the proposed size of backrest length (Purnomo and anto, 2016). In this present study, it is found that there is a large difference between the existing backrest length with proposed backrest length. This is because the existing backrest is used by 2 students. So, it is necessary to split the backrest length and chair length for each student to make it more ergonomic.

Backrest Height

The dimensions of shoulder height is used to design the height dimension of the backrest. The seat shoulder height used is the 95th percentile. The backrest height is calculated from 0.8 of seat shoulder height. This is in line with a study on classroom furniture in Izmir that shows that backrest height should be lower than scapula (Kaya, Erkarslan, and Kelimeler, 2019). In this research, the backrest height is 49.6 cm. this is in line with research in India suggesting that a backrest height is 500 mm (Wilson and Desai, 2017). The difference between the existing backrest height and the proposed backrest height reaches 7.6cm. Thus, the ergonomic backrest height change is needed because inappropriate backrest height can cause awkward posture, whichcan cause pain of spine (Castellucci and Catal, 2016). Lower backrest height is a risk factor of low back pain among students (Rezapur-Shahkolai, 2020).

Table Height

The dimension of table height is formed based on the size of the chair height, elbow height in the sitting position, and shoulder height in the sitting position. This is in line with previous research in Indonesia stating that the ergonomic table height is obtained from the chair height, elbow height and shoulder height (Yanto, Lu and Lu, 2017). The size used is the 5 percentile of each dimension. The table height in this study is found to be 57.1 cm. In another study in India, a table height of 555 mm is obtained (Wilson and Desai, 2017).

In this present study there is a difference of about 18.9 cm between the height of existing tables and the proposed table height according to the student anthropometry. The height of the existing table is considered too high, so the change is needed for more ergonomic tables. The table height that does not match the size of the body can cause fatigue of shoulder because too much energy is used to reach the table, and this can also cause

spinal disorders (Castellucci and Catal, 2016). The higher the table, the higher the risk factor related to neck and shoulder pain (Gheysvandi et al., 2019). Some students also findit difficult to write or read on the table because the table is too high, so students do many movements to reach the table. Many movements the students do are signs of discomfort (Fasulo, Naddeo, and Cappetti, 2019).

Table Width

The table width is designed based on the size of the distance of the elbow to the fingertips. The size used is 95th percentile from the elbow to the fingertips with the allowance of 0.5 cm. This is in line with research in India which uses 95th percentile of elbow length to design the table width (Wilson and Desai, 2017). Another research in Erbil also uses 95th percentile of forearm length to design the proposed size of table width (Abdullah and Ahmad, 2020). In this research, the table width is 39.5 cm.

Underneath Desk Height

Underneath desk height is designed based on the dimensionof knee height. The knee height used is 95th percentile plus 4 cm. This is in line with the results of other studies, suggesting that the dimension used for underneath high desk is the 95th percentile of knee height (Yanto, Lu and Lu, 2017; Altaboli et al., 2015). Proper underneath desk height is used so that students can sit comfortably and stand up easily from a chair and facilitate leg movements (Parvez et al., 2018).

In this study, the proposed size of underneath desk high is 47 cm. Another study mentions that underneath desk height is 50cm (Yanto, Lu and Lu, 2017). There is a difference in size due to differences in anthropometric size of the study subjects. In this study, there is a fairly large difference for underneath desk high dimensions of the existing size with a proposed size of 7 cm. Thus, this needs to be a concern for change.

The use of non-ergonomic school desks and chairs also has several adverse health effects. However, this study has not shown the health effects experienced by the students. Therefore, further research is needed on the health effects felt by the elementary school students.

CONCLUSION

This study is conducted based on the measurements on 7 dimensions of student anthropometry, which are used to determine the sizes of the ergonomic tables and chairs that are appropriate to the size of the students' body. There are 7 dimensions of proposed sizes of tables and chairs that have been measured, namely chair height, chair width, height of backrest, length of backrest, height of table, table width, and underneath desk height. The size of existing tables and chairs still needs improvement in all dimensions because there is still a difference between the existing sizes of tables and chairs with the proposed sizes of tables and chairs that are appropriate for the students' anthropometry. It is hoped that the proposed table and chair sizes can be applied in schools, and students can concentrate fully when studying in class.

REFERENCES

Abdullah, R. N. and Ahmad, A. N. (2020) 'Evaluation of Ergonomic Design of Desk and Chair For Primary Schools in Erbil City', *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 11(6), pp. 1–14.

Altaboli, A. et al. (2015) 'Anthropometric Evaluation of the Design of the Classroom Desk for the Fourth and Fifth Grades ofBenghazi Primary Schools', *Procedia Manufacturing*, 3(Ahfe), pp. 5655–5662.

Ansari, S., Nikpay, A. and Varmazyar, S. (2018) 'Design and Development of an Ergonomic Chair for Students in Educational Settings', *Health Scope*, 7(4), pp. 1–9.

Brewer, J. M. et al. (2009) 'Does Ergonomic Mismatch at School Impact Pain in School Children?', *Work*, 34(4), pp. 455–464.

Castellucci, H. I., Arezes, P. M. and Molenbroek, J. F. M. (2014) 'Applying Different Equations to Evaluate the Level of Mismatch between Students and School Furniture', *Applied Ergonomics*, 45(4), pp. 1123–1132.

Castellucci, H. I. and Catal, M. (2016) 'Evaluation of the Match between Anthropometric Measures and School Furniture Dimensions in Chile', *Work*, 53(3), pp. 585–595.

Fasulo, L., Naddeo, A. and Cappetti, N. (2019) 'A Study of Classroom Seat (dis) Comfort : Relationships between Body Movements, Center of Pressure on the Seat, and Lower Limbs' Sensations', *Applied Ergonomics*, 74(28), pp. 233–240.

Fidelis, O. P. et al. (2018) 'Ergonomic Analysis of Classroom Furniture in a Nigerian University', *Nigerian Journal of Technology*, 37(4), pp. 1154-1161.

Fidelis, O. P., Ogunlade, B. and Adelakun, S. A. (2020) 'Incidence of School Furniture Mismatch and Health Implications in Primary School Children in Akure , South-West Nigeria Incidence of School Furniture Mismatch and Health', *Journal of Occupational Therapy, Schools, & Early Intervention*, 13(1), pp. 1–13.

Gheysvandi, E. et al. (2019) 'Neck and Shoulder Pain among Elementary School Students: Prevalence and its Risk Factors', *BMC Public Health. BMC Public Health*, 19(1299), pp. 1–11.

Kaya, N. A., Erkarslan, Ö. and Kelimeler, A. (2019) 'Mismatch Between Classroom Furniture And Student Body Dimensions : Case Of Izmir', *Ergonomi*, 2(3), pp. 167–177.

Panagiotopoulou, G. et al. (2004) 'Classroom Furniture Dimensions and Anthropometric Measures in Primary School', *Applied Ergonomics*, 35(2), pp. 121–128.

Parvez, M. S. et al. (2018) 'Design of Ergonomically Fit Classroom Furniture for Primary Schools of Bangladesh', *Journal of Engineering*, 2018, pp. 1–9.

Pérez-gosende, P. (2017) 'Anthropometry-based Approach for Side-Mounted Desktop Chairs Design Evaluation for University Students in Ecuador', *IEEE Ecuador Technical Chapters Meeting (ETCM)*, 2017(April), pp. 1–5.

Pheasant, S. (2016) *Bodyspace: Anthropometry, Ergonomics and the Design of Work*. 3rd edn. London: CRC Press.

Purnomo, H. and anto, F. (2016) 'Design of School Furniture for First- to Sixth-Grade Classrooms in Special Region of Yogyakarta, Indonesia', *Journal of Ergonomics*, 06(03), pp. 1-8

Rezapur-Shahkolai, F. (2020) 'Risk Factors for Low Back Pain among the Elementary School Students, using Penalized Logistic Regression', *Epidemiology and Health*, 42(37), pp. 1–18.

Ridgers, N. D. et al. (2012) 'Agreement between ActivPAL and ActiGraph for Assessing Children's Sedentary Time', *International Journal of Behavioral Nutrition and Physical Activity*, 9(15), pp. 1–8.

Rimes, P. G. and Egg, S. L. (2004) 'Musculoskeletal Disorders (MSD) in School Students as a Risk Factor for Adult MSD : A Review of the Multiple Factors Affecting Posture , Comfort and Health in Classroom Environments', *Journal of the Human-Environmental System*, 7(1), pp. 1–9.

Rosyidi, C. N. et al. (2014) 'Mismatch analysis of elementary school desk and chair key characteristics in Indonesia', 660(1), in Applied Mechanics and Materials, pp. 1057–1061.

Saes, M. de O. (2015) 'Prevalence of Musculoskeletal Pain and its Association with Inadequate School Furniture', *Revista Dor. São Paulo*, 16(2), pp. 124–128.

Salunke, P. (2015) 'Identifying Anthropometric Parameters Considered for The Improvement in Ergonomic Design of Classroom Furniture', *International Journal of Industrial Engineering Research and Development*, 6(1), pp. 1–13.

Sevillaa, consuelo G. et al. (2007) *Research Methods*. Quezon City: Rex Printing Company.

Wilson, I. and Desai, D. A. (2017) 'Anthropometric Measurements for Ergonomic Design of Students' Furniture in India', *Engineering Science and Technology, an International Journal*, 20(1), pp. 232–239.

Yanto (2018) 'Pratinjau Ukuran Meja dan Kursi Anak Sekolah Menurut Acuan SNI Berdasarkan Dimensi Tubuh Siswa Kelas Satu Sekolah Dasar di DKI Jakarta', *Jurnal Metris*, 19(1), pp. 19–24.

Yanto, Lu, C. and Lu, J. (2017) 'Evaluation of the Indonesian National Standard for Elementary School Furniture based on Children's Anthropometry', *Applied Ergonomics*, 62(16), pp. 168–181.

Zakeri, Y. et al. (2016) 'The Relationship between Features of Desks and Chairs and Prevalence of Skeletal Disorders in Primary School Students in Abadan, South West of Iran', *International Journal of Pediatrics*, 4(11), pp. 3949–3956.