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EVALUATION OF THE CLASSROOM FURNITURE FOR UNIVERSITY STUDENTS

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Research Article

Üniversite Öğrencileri İçin Sınıf Mobilyalarının Değerlendirilmesi

Öz

Kişilerin sosyal, kültürel, ekonomik ve psikolojik ihtiyaçlarını karşılarken kullandıkları araç, gereç ve donanımların uygun tasarımı maksimum düzeyde fayda sağlamaktadır. Bu durum zamanının birçoğunu masa ve sıralarda geçiren okul öğrencileri için büyük önem arz etmektedir. Bu çalışmanın amacı, okul mobilya boyutlarının öğrencilerin antropometrik ölçülerine uygunluğunu araştırmaktır. Eskişehir Osmangazi Üniversitesi Mühendislik-Mimarlık Fakültesi'nde öğrenim gören 68'i kız, 157'si erkek olmak üzere toplam 225 öğrenciden, tasarlanan ölçüm aletiyle, 11 antropometrik ölçüsü alınmıştır. Mevcut sınıf mobilya ebatları ve öğrencilerin antropometrik ölçüleri karşılaştırılmıştır. Sonuçlar, mevcut ikili sıraların öğrenciler için önemli ölçüde uygun olduğunu göstermiştir..

Anahtar Kelimeler : *Antropometrik ölçü, Sınıf mobilyası, Üniversite öğrencisi*

Evaluation of the Classroom Furniture for University Students

Abstract

The appropriate design of tools, equipment and accessories for human body sizes, used while meeting the social, cultural, economic and psychological needs of people, is satisfied maximum beneficial. This is very crucial for school students who spend most of their time on the school furniture. The purpose of the study is to examine whether school furniture dimensions match student's anthropometric measures. Eleven anthropometric measurements are taken from 68 female and 157 male students from nine departments at the faculty of Engineering and Architecture of Eskişehir Osmangazi University using a specially designed measurement tool. The existing classroom furniture dimensions and the anthropometric measures of the students are compared in order to determine the match between them. The results indicated that the existing furniture is comprehensively adequate suitable for the students.

Keywords : *Anthropometric measure, Classroom furniture, University student.*

1. Introduction

Anthropometry consists of the measurement of body characteristics such as reach, body segment length and circumferences, widths and heights, among others. This information can be used to inform the design of tools, equipment, work station and clothes (Pheasant, 1998). During the design phase, incorporating the information from anthropometry would yield more efficient designs, ones that are more user friendly, safer and enable higher performance and productivity. The lack of properly designed machines and equipment may reduce the work performance and increase the frequency of work-related injuries (Botha and Bridger, 1998).

Anthropometric data for different populations vary greatly. The collection of anthropometric data is extremely time-consuming and expensive. There are many sources of anthropometric data for national populations, which can be found in papers in scientific journals (İşeri and Arslan, 2009) such as Dewangan et al. (2005) for Indian agricultural workers, Xiao et al. (2005) for Chinese, Klamklay et al. (2008) for Thai,

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Barroso et al. (2005) for Portuguese, Mokdad (2002) for Algerians.

In Turkey, there are very few studies on anthropometry. The most extensive study is the Anthropometric Survey of Turkey (Government Statistics Department, 1937). This survey was conducted in 10 regions of Turkey under the executive orders of Atatürk, the founder of the Republic of Turkey. In this survey, weight, height, span and sitting height were measured. Another study was done by Çiner (1960). In this study, anthropometric characteristics of 2501 females between the ages of 18 and 40 were measured from different regions of Turkey. Özok (1981)'s study was the first attempt from the engineering perspective of anthropometrics. The study took a sample of 1000 workers from 50 different industrial facilities. Kayış and Özok (1989) conducted a comprehensive survey on Turkish army personnel in which 51 different anthropometric measurements were taken from 5109 soldiers. Gönen and Kalınkara (1993) also conducted a small survey with only 195 participants on female population. The last comprehensive study was done by İşeri and Arslan (2009) to estimate the anthropometric characteristics of the Turkish population. It has a sample size of 4205 civilian subjects consisting of 2263 male and 1942 female.

During their lives, children spend approximately quarter of the day at school, and 80% of that time sitting down doing their school work. Considering the amount of time spent at school and specifically while sitting, it is fundamental that school furniture suit the children's requirements (Savanur et al., 2007), and it should also allow for the changing of posture (Yeats, 1997). Many authors have tried to establish theoretical recommendations for the principles that relate school furniture design to children's anthropometry, and some have also attempted to define the "appropriate" dimensions for school furniture based on anthropometric measurements (Gouvali and Boudolos, 2006). There have been studies related to school furniture design that have investigated differences in body dimensions due to age and gender. In some countries, there were attempts to design desk and chairs based on anthropometric data (Oyewole et al., 2010; Thariq et al., 2010).

A mismatch between school furniture dimensions and children's anthropometric measures have been reported in recent studies among several countries. This mismatch carries some potential negative implications. For example, learning is affected since uncomfortable and awkward body postures can impair the students' learning interest, even during the most stimulating and interesting lessons (Hira, 1980; Castellucci et al., 2010). Parcells et al. (1999) examined the mismatch between furniture and students' dimensions by measuring anthropometrics characteristics of American children. They reported that fewer than 20% of students can find acceptable chair/desk combinations.

Gouvali and Boudolos (2006)'s study focused on the suitability of school furniture to the anthropometric characteristics of Greek children using combinational equations modified in accordance with principles proposed by the literature. They determined that desk and seat height were bigger than the accepted limits for most children (81.8%), while seat depth was appropriate for only 38.7% of children.

Castellucci et al. (2010) compared furniture sizes within three different schools with the anthropometric characteristics of Chilean students in the Valparaiso region, in order to evaluate the potential mismatch between them. The sample consisted of 195 volunteer students of the 8th grade, ranging from 12.5 to 14.5 years of age from 3 different schools. Castellucci et al. (2014) reviewed the literature describing the criteria equations for defining the mismatch between students and school furniture. The sample used for testing the different equations was composed of 2261 volunteer subjects from 14 schools. Castellucci et al. (2015) reviewed the scientific literature that describes the criteria equations for defining the mismatch between students and school furniture. Seventeen studies met the criteria of this review and twenty-one equations to test six furniture dimensions were identified.

Recently, Thariq et al. (2010), Hossian and Ahmet (2010), Hoque et al. (2014) and Byuiyan and Hossian (2015) have given some studies to design ergonomically correct furniture for university students. Hoque et al. (2014) evaluated the potential mismatch between university classroom furniture dimensions and anthropometric measures of 500 Bangladeshi university students. Fifteen anthropometric measures and nine dimensions from the existing classroom furniture were measured and then compared together to identify and potential mismatch between them. The results indicated that the seat height was high. Bhuiyan and Hossian (2015) developed a methodology in designing ergonomic furniture used by the university hall students based on anthropometric measurements and using the artificial neural network (ANN). In study, two easy to measure anthropometric dimensions: 'stature' and 'weight' has been selected and ANN has been used to predict the other 35 difficult to measure linear anthropometric dimensions from the two easy-to-measure ones. A computer programme was developed to get the ergonomic design of furniture using these anthropometric dimensions of that particular person. A mismatch analysis was carried to determine the mismatches of furniture design resulting from this research in comparison to actual body dimensions.

Several studies have been conducted on the design ergonomically correct furniture for university students in Turkey. In the study conducted by Tunay et al. (2005),

anthropometric measurements to design school furniture were taken from 187 university students (45 female and 138 male) in Zonguldak Karaelmas University were chosen. The anthropometric measures of the students were gathered and then the dimensions of the school furniture were suggested. Dizdar and Okcu (2007) aimed to evaluate the existing design of the classroom furniture used in Bozok University. Data were gathered for a total of 143 students (37 female and 106 male). Several body dimensions were measured for each student. The anthropometric measures of the students and the furniture dimensions were compared in order to identify any incompatibility between them. Tunay and Melemez (2008) was carried out the necessary anthropometric measurements of classroom furniture used in Turkish higher education. The static anthropometric measures of 13 dimensions from 1049 students were obtained while they are standing and sitting. The data was analyzed to determine the limit values. The dimensions of school desks and chairs were compared with the student's anthropometric measures.

Some studies have acknowledged the importance of appropriate classroom furniture used in university education in Turkey but, in recent years, there is a few study investing relationship between school furniture and student anthropometric measures. This investigation examines whether the double desk of a faculty is appropriate for the students. As a result of the analysis, the suitability of the present school furniture for the students was investigated. This study would help in establishing and motivating the necessary further studies in classroom ergonomics.

2. Method

2.1. Measures

School furniture dimensions are grouped in three main dimensions (Figure 1);

- Seat (including backrest)
- Desk
- Interactions between desk and seat.

Table 1 shows a summary of relationships between school furniture dimensions and anthropometric measures (Castelluccci et al., 2014; Castelluccci et al., 2015). There are seven anthropometric measure required for the school furniture dimensions (Figure 2).

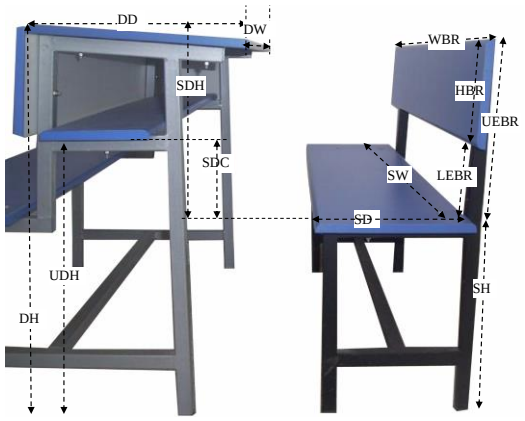
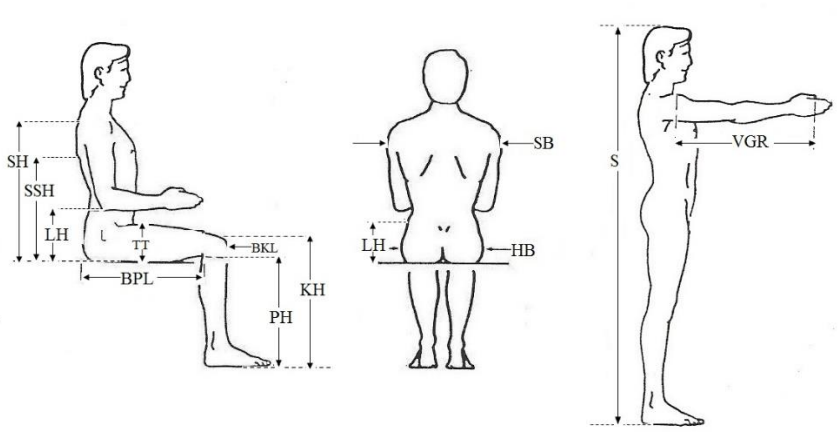


Figure 1. Double classroom furniture

Table 1. Relationship between anthropometric measures and school furniture dimensions

Component	School furniture dimension	Anthropometric measures
Seat	Seat Height (SH)	Popliteal Height (PH)
	Seat Width (SW)	Hip Breadth (HB)
	Seat Depth (SD)	Buttock Popliteal Length (BPL)
Backrest	Upper Edge of Backrest (UEBR)	Shoulder Height (SH)
		Subscapular height (SSH)
	Lower Edge of Backrest (LEBR)	Lumber Height (LH)
		LEBR = UEBR – HBR
	Height of Backrest (HBR)	Lumber height (LH)
	Width of Backrest (WBR)	Shoulder Breadth (SB)
	Slope	Functional criteria , ∼5°
Desk	Desk Height (DH)	Popliteal Height (PH) , Elbow Height (EH)
	Desk Depth (DD)	Functional criteria
	Desk Width (DW)	Functional criteria , Seat Depth (SD)
	Underneath Desk Height (UDH)	Knee Height (KH)
Interaction between	Seat to Desk Clearance (SDC)	Thigh Thickness (TT)
		Knee Height (KH)
desk and seat	Seat to Desk Height (SDH)	Elbow Height (EH)



S : Stature
SH : Shoulder Height
EH : Elbow Height
BKL : Buttock-Knee Length
BPL : Buttock- Popliteal Length
KH : Knee Height
PH : Popliteal Height
SB : Shoulder breadth
HB : Hip Breadth
VGR : Vertical Grip Reach
SSH : Subscapular Height
LH : Lumber Height
TT : Thigh Thickness

Figure 2. Anthropometric measures

The measures are taken from students using an anthropometric device, in standing and sitting positions while the subjects are without shoes, wearing casual dresses. Definitions for seven required measures and also four plus measures (stature (S), buttock knee length (BKL) , vertical grip reach (VGR) and weight (W)) are defined below (Özok, 1988; Pheasant, 1998; Dizdar and Okçu, 2007; Oyewole et al., 2010; Castellucci et al., 2014; Hoque et al., 2014; Castellucci et al., 2015).

Stature (S) : The vertical distance from the standing surface to the top of the head while the subject stands erect and looks straightforward.

Shoulder Height (SH) : The vertical distance from the top of the shoulder at the acromion process to the subject' s sitting surface. The data is used in design of work places, to place equipment and interior arrangements.

Elbow Height (EH) : The vertical distance from the bottom of the tip of the right elbow to the subject' s seated surface. The data is used in interior arrangements, to determine sitting object's armrest's height with work benches, desks, tables and special equipment.

Buttock-Knee Length (BKL): The distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal surface. The data is used when determining the distance from an object in front of knee or a physical obstacle to the backrest of sitting place, when placing sitting materials in theatre and meeting rooms, determining underneath heights of desks, tables and benchs.

Buttock- Popliteal Length (BPL) : The distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal surface. The data is used in interior layout arrangements and in design of siting places.

Knee Height (KH) : The vertical distance from the foot resting surface to the top of the knee cap. The data is used in interior arrangements, determining underneath heights of desks, tables and benchs.

Popliteal Height (PH) : The vertical distance from the popliteal space which is the posterior surface of the knee to the foot resting surface. The data is used to determine elevation from the ground of top surface of the sitting place and height of closets.

Shoulder Breadth (SB) : The horizontal distance across the maximum lateral protrusion of the right and left deltoid muscles. In standing position with clothing, distance between the shoulder muscles is measured with a big anthropometric device.

Hip Breadth (HB) : The maximum breadth of the lower torso while the subject stands erect and looks straightforward. The data is used in interior arrangements, to size clothing, to design equipment, to determine width of accommodation areas (seat, chair, stool, bar and office chairs etc.).

Vertical Grip Reach (VGR) : The vertical distance from the shoulder to the top of middle finger when arms are stretched forward.

Weight (W) : Weight measurement which is taken with daily dress.

2.2 Anthropometric Measurement Table Design

The necessary anthropometric measures for the classroom furniture dimensions were determined. It should be noted that there were different methods used for measuring body dimensions for the purpose of equipment design (Mokdad and Al-Ansari, 2009). The traditional anthropometric tools are simple and inexpensive. In this study, in order to provide reliable and quick measurement especially in siting position, a measurement tool was designed (Figure 3) and constructed to take the measures.

Figure 3. Anthropometric Measurement Tool

Provided facilities of measurement table usage;

- It takes a little time to collect four measures
- Sliding parts and fixed equipment provide convenience to measure.
- Less flexibility of materials which were used in design and usage of double-sided measurement rulers provide to take more sensitive measurements.
- During measurement of body dimensions, subjects don't be exposed to any difficulty.

In dimension design of measurement tool, it was based to studies conducted in England and America. Treadle of measurement tool and two plaque on the backrest were designed as sliding. For the purpose of taking shoulder breadth and hip breadth measures, two plaque were designed on the backrest of tool. Left plaque for shoulder breadth measure and right plaque for hip breadth measure is fixed, the other is removable. While subjects are sitting in an erect position on the table, measures should be taken on the left side for shoulder breadth and right side for hip breadth. Double-sided rule was fixed on the table to provide sensitivity for the measures.

2.3. Participants

This study involves undergraduate students from different levels and departments of the faculty of Engineering and Architecture. The measurements were taken from 225 students consisted of 68 female and 157 male. They come from nine departments and were ranged in age from 19 to 28 years with a mean of 22.08 years. Permission to conduct the research was obtained from the faculty management.

Prior to collecting data, three students were assigned. They have been extensively trained on the identification of the measurement procedure for accurate and precise measurement of the body dimensions. In this training, issues like; which point in the human body will be referred to for each measure, in which order the measurements will be made, which clothing of the student (participant) will be allowed during measurements, how to register these in the form and who will do what (distribution of tasks) during measurement were focused on.

2.4. Measurements

The measurement tool was placed to Ergonomics Laboratory in the department of Industrial Engineering. The participants were asked to come to the laboratory for the measurement. In this study, seven required and also four arbitrary measures were gathered from participants. Stature (S) and weight (W) with digital scale (Figure 4.a) and other nine measures with the measurement tool (Figure 4.b) were collected.

The measurements were taken in consideration with the method described by Pheasant (1998). During the measurement process, the subjects were without shoes and wearing light clothing.

While the subject was sitting on the table,

- Buttock popliteal length (BPH) with the support of sliding backrest forward and backward,
- Popliteal height (PH) with the support of sliding up and down treadle,
- Hip breadth (HB) with sliding right and left bottom plaque on the backrest
- Shoulder breadth (SB) with sliding right and left upper plaque on the backrest

can be measured directly. While the participants were sitting erect on the measurement table with knees bent at 90°, shoulder height (SH), elbow height (EH), buttock-knee length (BKL), knee height (KH) and vertical grip reach (VGR) were taken with the support of anthropometry set and tape measure.

The measures and demographic information such as the age, gender, grade level of each participant student were recorded to a measurement form.

a. Stature (S) and Weight (W)

b. Hip Breadth (HB)

Figure 4. Measurements

3. Results

Related to collected measurements, descriptive and percentage values (Mean, SD, Maximum, Minimum and percentages (%5, %95) for female and male students were given in Appendix 1.

In general researches about body measurements, %90 percent of user group were considered. %5 percent of the top and bottom were excluded from standard comprehension. Design studies intend to consider the population which stay between %5 percent and %95 percent (Tunay et al., 2005). In design of products which are used by both male and female, the standard dimensional specifications are based on anthropometric measures of the %5 percent (small) of females or %95 percent (large) of males

Seat Height (SH) : Most of the researchers have concluded that popliteal height should be higher than seat height, otherwise most students will be unable to rest their feet on the posterior surface of the knee (Castellucci et al., 2015). For the seat height, %5 percent of female's popliteal height (PH), 38.83 cm, is considered. When shoe correction with a height 2.5 cm is included, SH is obtained 41.33 cm.

Seat Width (SW) : To be able to relieve the pressure on the buttocks and to avoid discomfort and mobility restrictions, seat width should be higher than hip breadth (Oyewole et al., 2010). %95 percent of male's sitting hip breadth (HB), 45.36 cm, is considered. Because of measurements taken with clothing, dress correction isn't included. For double desks, consideration with a 20 cm space, seat width is found 110.72 cm.

Seat Width = Hip Breadth (HB) + 20 cm + Hip Breadth (HB)

Seat Width = 45.36 * 2 + 20 = 110.72 cm.

Seat Depth (SD) : Buttock popliteal length (PBL) is the anthropometric measure used to designate the size of the seat depth. Seat depth should be designed for the %5 percentile of PBL distribution, including even the shorter users. Gouvali and Boudolos (2006) sited that SD should be at least 5 cm shorter than PBL. It is suggested as 38.65 cm which is a total of %5 percent of female's sitting PBL (43.65 cm) and 5 cm space.

Upper Edge of Backrest (UEBR) : The dimension of the upper edge of backrest (UEBR) can be determined by subscapular height measure but because of difficulty of taking this measure on the student, this measure couldn't be collected from students. So, it was calculated by excluding 10 cm from the %95 percent of male's shoulder height (SH) (67.10 cm).

Height of Backrest (HBR) : It is more appropriate to use distance between subscapular and lumber height measures. Because of difficulty to measure from the students, this dimension can be assumed as 20 cm.

Width of Backrest (WBR) : 52.48 cm which is equal to %95 percent of male's shoulder breadth (SB) is considered. When 20 cm space is taken into account for double desk, the dimension is obtained 124.96 cm.

Backrest Slope : ~5° slope is recommended.

Desk Height (DH) : Elbow height (EH) (sitting) is major criterion for desk height measure. It is also accepted that elbow height can be considered as the minimum height of DH. Then, %5 percent of female's elbow height while sitting is considered for DH. Some researchers recommended that the desk should be 5 cm higher than elbow height.

Desk Height = Popliteal Height (PH) + Elbow Height (EH) + Shoe Correction + 5 cm

Desk Height = 38.83 + 21.94 + 2,50 + 5 = 68.27 cm

Desk Width (DW) : Because of the same dimensions of the desk, seat and backrest width, the biggest one of these dimensions (124.96 cm) is considered.

Desk Depth (DD) : Concerning table dimensions, it is important to mention that there are two dimensions, desk width (DW) and desk depth (DD) in which the relationships were not found. Castellucci et al. (2010) defined these dimension according to functional criteria such as the need for available desk surface to perform school activities, for instance reading and writing. An A4 paper and two 5 cm plus is calculated for the dimension which is 40 cm.

Underneath Desk Height (UDH) : Seat to Desk Clearance (SDC) has to be large enough in order to allow leg movements. Accordingly, SDC is considered appropriate when it is higher than thigh thickness (Castellucci et al., 2015). We decided that %95 percent of male's knee height should be considered. Parcells et al. (1999) proposed that the desk clearance should be 2 cm higher than knee height.

Underneath Desk Height = Knee Height (KH) + Shoe Correction + 2 cm

Underneath Desk Height = 61.40 + 2,50 + 2 = 65.90 cm

In consequence of analyzes, dimensions of double school furniture which are used in the Faculty of Engineering and Architecture (Figure 1), Standard of TSE (TSE, 2003) and dimensions of desk and seats which were calculated in this study are given in Table 2.

Table 2. Present and Suggested Double Desk and Seat Dimensions (cm)

Component	School furniture dimension	Present Dimensions	TSE Standard	Suggested Dimensions
Seat	Seat Height (SH)	43.5	45	41.33
	Seat Width (SW)	120	110	110.72
	Seat Depth (SD)	30	45	38.65
Backrest	Upper Edge of Backrest (UEBR)	35	32	57.10
	Lower Edge of Backrest (LEBR)	15	10	37
	Height of Backrest (HBR)	20	22	20
	Width of Backrest (WBR)	120	110	124.96
	Slope	3°	6°	5°
Desk	Desk Height (DH)	75.5	77	68.27
	Desk Depth (DD)	39.5	40	40.00
	Desk Width (DW)	120	110	125.96
	Slope	4°	-	8°
	Underneath Desk Height (UDH)	57.5	57.5	65.90

4. Conclusions

This paper intended to analyze the relation between anthropometric measures from a sample of 225 university students and the classroom furniture dimensions. A measurement tool was designed to take the required measures easily and placed to Ergonomics Laboratory in the department of Industrial Engineering. The participants were asked to come to the laboratory for the measurement. The measures were taken from 225 students consisted of 68 female and 157 male. As a result of the analysis, the suitability of the present school furniture for the students was investigated.

When considered the basic of student's anthropometric measures, some final remarks in dimensions of present double desks can be summarized as follows.

- According to student's anthropometric measures, seat height is 2 cm higher and desk height is 7 cm higher. However, when shoe correction is considered with 4 cm for female students, the dimensions are acceptable.

  Most remarkable deficiency is related to seat depth. It is about 9 cm short, almost half of the leg is out of the desk. 38.65 cm depth is reasonable for chairs, armchairs etc. but desk depth can be a bit much due to difficulty of sitting and standing.

- For backrest dimensions, it is necessary to take subscapular and lumber height measures which is quite hard to gather from students. Because of production easiness, upper edge of backrest is considered equal to desk height, although it is not appropriate.

- Desk width dimension is acceptable. Because desk, seat and backrest width should be same dimension, each dimension is a close value to present the value, 120 cm.

Depth dimension was obtained 40 cm. It should be though that when considered another education materials on the desk, this measurement is the least.

If desks can be done 8° slope to forward, in sitting backward position, perception of losing desk's control is disappeared (Babalık, 2016).

- Desk shelf height is the difference between desk height (68.27 cm) and underneath desk height (65.90 cm). This height, only 2.37 cm, is low to put any object to desk self. It is recommended that the self should be removed from the desk or %50 percent of male's knee height should be considered for the underneath desk height. However the (net) desk shelf height of the existing desk is 14 cm.

While sitting and leaning backwards, in order to avoid from the back and muscle pains, the design of backrest and seat can be recommended according to the body position. It should not be forgotten during writing that if desk height is taken above determined measure, shorter students will get tired more quickly and if it is taken below from determined measures, taller students will be exposed to low back pain.

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Conflict of Interest

No conflict of interest was declared by the authors.

References

Babalık, F.C. (2016). *Mühendisler İçin Ergonomi İşbilim*, Dördüncü Baskı, Dora Yayın Dağıtım Ltd. Şti., Bursa, 620 s.

Barroso, M.P., Arezes, P.M., Costa, L.G. and Miguel, A.S. (2005). Anthropometric Study of Portuguese Workers. *International Journal of Applied Ergonomics,* 35, 401-410.

Bhuiyan, T. H. And Hossain, M. S. J. (2015). University Hall Furniture Design Based on Anthropometry : An Artificial Neural Network Approach. *International Journal of Industrial and Systems Engineering*, 20(4), 469-482.

Botha, W.E. and Bridger, R.S. (1998). Anthropometric Variability, Equipment, Usability and Musculoskeletal Pain in a Group of Nurses in the Western Cape. *International Journal of Applied Ergonomics,* 29 (6), 481-490.

Castellucci, H.I., Arezes, P.M. and Viviani, C.A. (2010). Mismatch Between Classroom Furniture and Anthropometric Measures in Chilean Schools. *Applied Ergonomics,* 41, 563-568.

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, 1123-1132.

Castellucci, H.I., Arezes, P.M. and Molenbroek, J.F.M. (2015). Equations for Defining the Mismatch Between Students and School Furniture : A Systematic Review. *Applied Ergonomics,* 48, 117-126.

Çiner, R. (1960). Türkiye Kadınlarının Antropolojisi. *Ankara Üniversitesi Dil ve Tarih Coğrafya Fakültesi Dergisi,* 18, 3-4.

Dizdar, E. N. and Okçu, O. (2007). Yüksek Öğrenim Öğrencileri Antropometrik Boyutlarının Tesbiti İle Sıra ve Masa Boyutlarına Uygulanması. *13. Ulusal Ergonomi Kongresi,* Kayseri, 6-8 Aralık 2007.

Dewangan, K.N., Prasanna Kumar, G.V., Suja, P.L. and Choudhury, M.D. (2005). Anthropometric Dimensions of Farm Youth of the North Eastern Regions on India, *International Journal of Applied Ergonomics,* 35, 979-989.

Gouvali, M.K. and Boudolos, K. (2006). Match Between School Furniture Dimensions and Children's Anthropometry, *Applied Ergonomics.* 37, 765-773.

Government Statistics Department (1937). *Türkiye Antropometri Anketi*, Başbakanlık İstatistik Umum Müdürlüğü, Yayın No:151.

Gönen, E. and Kalınkara V. (1993). Üniversiteye Devam Eden Kız Öğrencilerin Boyutsal Ölçülerinin Incelenmesi. 4*. Ulusal Ergonomi Kongresi.* MPM Yayın No:509, 93-107, Ankara.

Hira, D.S. (1980). An Ergonomic Appraisal of Educational Desks. *Ergonomics,* 23, 213-221.

Hoque, A.S.M., Parvez, M.S., Halder, P.K. and Szecsi, T. (2104). Ergonomic Design of Classroom Furniture for University Students of Bangladesh. *Journal of Industrial and Production Engineering,* 31(5), 239-252.

Hossain, M. S. J. and M. T. Ahmed, M.T. (2010). An Anthropometric Study to Determine the Mismatches of Furniture Used By Bangladeshi University Students A Case Study : Bangladesh University of Engineering And Technology (BUET)," iDECON

2010: International Conference on Design and Concurrent Engineering, Melaka, Malaysia.

İşeri, A. and Arslan, N. (2009). Estimated Anthropometric Measurements of Turkish Adults and Effects of Age and Geographical Regions. *International Journal of Applied Ergonomics,* 39, 860-865.

Kayış, B. and Özok, A.F. (1989). Türk Erkek Toplumunun Antropometrik Ölçülerinin Belirlenmesi. *Türkiye Bilimsel ve Teknik Araştırma Kurumu*, Rapor No: a 71.

Klamklay, J., Sungkhapong, A., Yodpijit, N. and Patterson, P.E. (2008). Anthropometry of the Southern Thai Population. *International Journal of Applied Ergonomics,* 38, 111-118.

Mokdad, M. (2002). Anthropometric Study of Algerian Farmers. *International Journal of Applied Ergonomics,* 29, 331-341.

Mokdad, M. and Al-Ansari, M. (2009). Anthropometrics for the Design of Bahraini School Furniture. *International Journal of Industrial Ergonomics,* 39, 728-735.

Oyewole, S.A., Haight, J.M. and Freivalds, A. (2010). The Ergonomic Design of Classroom Furniture / Computer Work Station for First Graders in the Elementary School. *International Journal of Applied Ergonomics,* 40, 437-447.

Özok, A.F. (1981). Türk Sanayi İşçileri Üzrine Antroepometrik Bir Araştırma. *Türkiye Bilimsel ve Teknik Araştırma Kurumu*, Proje No:MAG-533.

Özok, A. F. (1988). Ergonomik Açıdan Çalışma Yeri Düzenleme ve Antropometri, *Türk Metal Sen.*, No: 125, İstanbul.

Pheasant, S. (1998). *Bodyspace : Anthropometry, Ergonomics and the Design of Work*, Second Ed., Taylor and Francis, London.

Parcells, C., Manfred S. and Hubbard, R. (1999). Mismatch of Classroom Furniture and Body Dimensions. Empirical Findings and Health Implications. *Journal of Adolescent Health,* 24, 265-273.

Savanur, C.S., Altekar, C.R. and De, A. (2007). Lack of Conformity Between Indian Classroom Furniture and Student Dimensions : Proposed Future Seat/Table Dimensions. *Ergonomics,* 50, 1612-1625.

Thariq, M.G.M, Munasinghe, H.P. and Abeysekara, J.D. (2010). Designing Chairs with Mounted Desktop for University Students : Ergonomics and Comfort Classroom. *International Journal of Industrial Ergonomics,* 40, 8-18.

TSE, 2003, *Mobilya-Eğitim Kurumlarında Kullanılan Sandalyeler ve Masalar, Bölüm I : Fonksiyonel Boyutlar*, Türk Standardı, TS 3585 ENV 1729-1, Ankara.

Tunay, M., Melemez, K. and Dizdar, E. N. (2005). Yüksek Öğrenimde Kullanılan Okul Sıra ve Masalarının Antropometrik Tasarımı (Bartın Orman Fakültesi Örneği). *Teknoloji*, 8 (1), 93-100.

Tunay, M. and Melemez, K. (2008). An Analysis Of Biomechanical and Anthropometric Parameters on Classroom Furniture Design. *African Journal of Biotechnology*, 7 (8), 1081-1086.

Yeats, B. (1997). Factors that may influence the postural health of schoolchildren (K-12). Work : A journal of Prevention. *Assessment & Rehabilitation,* 9, 45-55.

Xiao, G., Lei, L., Dempsey, P.G., Luc, B. and Liang, Y. (2005). Isometric Muscle Strength and Anthropometric Characteristics of a Chinese Sample. *International Journal of Applied Ergonomics,* 35, 674-679.

Appendix 1. Anthropometric Measures of Students (cm)

a. Female Students

	Measure	Min	%5	Mean	Std. Dev.	%95	Max
S	Stature	153.00	153.92	163.22	5.64	172.52	176.50
SH	Shoulder Height	52.50	54.08	58.58	2.73	63.08	64.50
EH	Elbow Height	21.50	21.94	25.61	2.23	29.29	31.50
BKL	Buttock-Knee Length	46.00	53.40	58.65	3.18	63.90	66.00
BPL	Buttock- Popliteal Length	43.00	43.65	49.29	3.41	54.92	67.00
KH	Knee Height	47.00	47.73	51.00	1.98	54.28	55.00
PH	Popliteal Height	38.00	38.83	43.22	2.66	47.61	54.50
SB	Shoulder breadth	37.00	36.74	40.32	2.17	43.89	45.50
HB	Hip Breadth	35.00	35.00	38.42	2.07	41.84	43.50
VGR	Vertical Grip Reach	69.00	69.26	75.01	3.49	80.77	82.50
W	Weight (kg)	42.00	45.05	56.55	6.97	68.06	76.00

b. Male Students

	Measure	Min	%5	Mean	Std. Dev.	%95	Max
S	Stature	155.00	166.48	178.00	6.98	189.51	199.50
SH	Shoulder Height	54.50	57.83	62.46	2.81	67.10	70.00
EH	Elbow Height	20.50	20.95	26.57	3.40	32.18	55.00
BKL	Buttock-Knee Length	57.00	59.13	64.88	3.49	70.64	77.00
BPL	Buttock- Popliteal Length	46.00	47.83	53.17	3.24	58.51	61.50
KH	Knee Height	49.00	51.82	56.61	2.90	61.40	67.50
PH	Popliteal Height	40.50	43.26	48.10	2.93	52.93	66.00
SB	Shoulder breadth	38.00	42.34	47.41	3.07	52.48	58.00
HB	Hip Breadth	34.50	35.84	40.60	2.89	45.36	49.00
VGR	Vertical Grip Reach	72.00	76.54	84.14	4.61	91.74	99.00
W	Weight (kg)	50.90	55.63	78.57	13.90	101.51	138.80