

*Short Communication***Proportion of elementary school pupils' anthropometric characteristics with dimensions of classroom furniture in Isfahan, Iran***Ehsanollah Habibi^{a*}, Zahra Asadi^b, Seyed Mohsen Hosseini^c***Abstract**

BACKGROUND: This study is aimed to examine the appropriacy of school furniture to Iranian pupils' anthropometric features.

METHODS: The participants in this cross-sectional study were 493 boys and 489 girls with the age-range of 7 to 12 years who were selected through a multistage random cluster sampling procedure. Age, weight, height, and anthropometric dimensions were determined.

RESULTS: This study indicates that there is a significant difference between the minimum and maximum acceptable dimensions and those of the available furniture ($p < 0.001$).

CONCLUSIONS: In designing suitable furniture for pupils the anthropometric differences of age and gender must be taken into account.

KEYWORDS: Ergonomics, Anthropometry, Furniture.

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Designing suitable and comfortable workstation that helps increasing efficiency of work force establishes the principal philosophy of ergonomics. It is important that the design of workstation be physically and psychologically proportionate to users.¹ In fact, school is a working environment of billions of students which has not amply been considered by ergonomics researchers.² At school, students spend most of their time in class and in a sedentary position.³⁻⁵

Anthropometric sizes of students are an important factor that should be considered in designing school furniture.^{6,7} Some studies have confirmed the lack of conformity between anthropometric sizes of students and dimensions of used furniture. Moreover, the number of students suffering from musculoskeletal disorders is increasing.⁸ Headache, ache in

neck and shoulder muscles, decrease in concentration, lack of spirit, and tiredness of eyes are very common among students and these problems are increasing.^{4,9-12}

In Iran, some studies have been done in Mazandaran and Qazvin provinces in order to measure students' body dimensions and consequently design suitable furniture considering available anthropometric differences in age and sex.¹³⁻¹⁵

Methods

This cross-sectional study was carried out from 2008 to 2009 and 982 pupils including 489 girls (49.7%) and 493 boys (50%), aging 7 to 12 years old from 38 different primary schools from 5 educational area in Isfahan, Iran were selected by a multistage cluster sampling procedure. Their height, weight, age, and necessary an-

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thropometric dimensions (shoulders height, height of elbow support, knee height and popliteal height, buttock-popliteal length and hip breadth) were measured on the basis of standard body postures and in a static sedentary position, with uniform clothes, and without shoes.

Different kinds of the available furniture in schools were studied and it was found that two old (Figure 1) and new (Figure 2) designs are in use in schools.

Old design includes furniture connected to each other for three pupils in three different sizes. The first size is for first graders, the second size is for second to fourth graders and the third size is for fifth-graders.



Figure 1. A sample of old designs of available furniture for schools

New design includes furniture which is separated from each other which two pupils use a common desk and have two different sizes. The First size is for the first to fourth-grade pupils and the second size is for the fifth-grade pupils. Sizes of the seat height, the seat depth, the seat width, desk height, underneath desk

height, slope of the seat and slope of the desk backrest were specified (Table 1).



Figure 2. A sample of new designs of furniture available for schools

Results

The present study measured 8 anthropometric dimensions. Table 2 shows descriptive and percentile values for the male and female student dimensions. Anthropometric dimensions of students vary by gender and age. In other words, growth pattern differs by age and sex. According to the findings, until the age of 9, mean anthropometric dimensions of boys are greater than those of girls, but at the age of 9 to 12, girls tend to be bigger than boys. For example, in 8-year-old boys, the mean weight, stature, shoulder height, and hip breadth are equal to 26.5 kg, 127.3 cm, 42.7 cm and 24.2 cm, respectively, whereas in girls of the same age, these values are 25.2 kg, 125.3 cm, 42.3 cm and of 24.4 cm, respectively (Table 2).

Table 1. Furniture characteristics (mean and standard deviation)

		The seat height (cm)	The seat depth (cm)	The seat width (cm)	Height of backrest (cm)	Desk height (cm)	Underneath desk height (cm)	The seat slope (degree)	Slope of desk backrest (degree)
Old design	Size 1	35 (0.093)	21.6 (0.3)	30 (0.4)	36.9 (0.09)	68 (0.09)	50.6 (0.04)	0	90
	Size 2	41.8 (0.4)	24.1 (0.5)	40.1 (0.2)	28.8 (0.1)	69.3 (0.3)	55.3 (0.4)	0	90
	Size 3	43.4 (0.08)	24.4 (0.04)	36.6 (0.1)	28.1 (0.04)	69.1 (0.1)	54.4 (0.04)	0	90
New design	Size 1	36.5 (0.3)	34 (0.09)	36 (0.09)	37.7 (0.2)	66.6 (0.5)	53.5 (0.3)	0	90
	Size 2	40.3 (0.4)	37.4 (0.4)	37 (0.02)	39.2 (0.2)	69.2 (0.4)	55.5 (0.4)	0	90

Table 2. Mean and standard deviation and 95% percentiles for anthropometric dimensions of male and female students (G: girls; B: boys)

Age	Sex	Weight	Stature	Shoulder height		Elbow rest height			Popliteal height			Knee height			Buttock-popliteal height			Hip breadth			
		Mean (SD)	Mean (SD)	Mean (SD)	5th	95th	Mean (SD)	5th	95th	Mean (SD)	5th	95th	Mean (SD)	5th	95th	Mean (SD)	5th	95th	Mean (SD)	5th	95th
7	G	24.2 (5.4)	121 (5.9)	41.4 (2.9)	37.4	46.6	16.8 (1.9)	14.1	19.6	30.4 (2.4)	26.3	33.7	36.6 (2.5)	32.0	40.6	30.7 (3.2)	26.1	36.0	24.1 (3.2)	19.9	28.7
	B	24.6 (5.6)	122.9 (6.3)	41.8 (3.1)	36.9	46.4	17.1 (1.6)	14.4	20.1	31.3 (2.5)	26.9	35.9	37.3 (2.5)	32.6	42.1	31.4 (2.5)	27.2	34.7	24.1 (2.4)	20.3	28.4
8	G	25.2 (5.1)	125.3 (6.9)	42.3 (3)	37.7	47.4	17.1 (1.9)	14.1	20.3	31.8 (2.5)	27.5	35.8	38.2 (2.7)	33.8	42.4	32.6 (3)	27.9	37.4	24.5 (2.4)	20.9	28.7
	B	26.5 (5.8)	127.3 (6.3)	42.8 (2.7)	38.3	47.9	17.6 (2)	14.8	20.8	32.6 (2.3)	28.2	37.9	38.8 (2.7)	33.9	44.5	31.8 (2.5)	28.2	36.1	24.8 (2.7)	21.3	29.2
9	G	29.8 (6)	131.7 (5.9)	44.8 (3)	39.7	49.8	18.4 (2)	14.9	21.6	34.1 (2.8)	29.2	38.4	40.6 (2.7)	36.0	45.0	34.6 (2.6)	30.3	39.2	26.2 (2.5)	22.3	30.4
	B	29 (7.1)	131.2 (7)	44.3 (3.1)	39.5	49.7	18.2 (1.9)	15.3	21.8	34.3 (2.7)	29.5	39.9	40.2 (3)	35.1	44.6	33.2 (2.5)	29.2	37.7	25.3 (2.3)	22.1	30.0
10	G	34 (7.8)	137.1 (7.5)	46.6 (3.3)	41.4	52.3	18.7 (2.1)	15.5	22.4	35.9 (3)	31.2	40.6	42.5 (3)	37.7	47.6	36.7 (2.5)	32.3	41.4	27.8 (2.7)	23.2	32.5
	B	33.6 (9.6)	137.2 (7.6)	46.4 (3.4)	41.0	52.3	19 (1.9)	15.8	22.6	36.2 (2.9)	30.9	41.9	42.6 (3)	36.7	48.6	34.5 (2.8)	30.2	39.3	26.7 (2.9)	22.8	31.3
11	G	37.7 (10.6)	143.5 (9)	49.1 (4.1)	43.1	55.3	19.8 (2.3)	15.5	22.4	38.1 (3.5)	33.8	42.5	44.7 (3.7)	39.5	50.1	38.2 (3.5)	33.4	43.7	28.7 (3.4)	23.9	34.3
	B	37.3 (9.5)	142.0 (7.1)	48.0 (4.1)	42.1	54.4	19.1 (2.4)	15.7	22.8	37.7 (2.8)	32.1	43.6	44.0 (3.4)	38.2	44.3	36.2 (3)	31.4	36.2	27.6 (2.9)	23.2	32.6
12	G	41.8 (9.7)	145.1 (6.4)	51.2 (3.5)	45.1	57.3	20.3 (2.8)	17.1	24.2	39.9 (2.7)	35.8	43.4	46.0 (3.1)	41.0	51.5	40.3 (3.1)	35.5	44.8	30.1 (2.8)	25.6	35.6
	B	38.9 (11.4)	148.3 (7.3)	48.3 (3.6)	42.2	55.1	19.2 (2.2)	15.4	22.7	40.1 (3.3)	33.5	46	46.5 (4)	40.0	51.8	37.6 (3.4)	32.4	42.1	28.1 (3.6)	23.3	33.3

Regarding the seat height in sizes 1, 2, 3 of the old design, the proportion rate with pupils is 15.8, 8.5 and 30.9 percent, respectively. Size 1 and 2 of the new design are proportionate to 43.4 and 59.2 percent of pupils. However, for 83.7, 91.3 and 69.1 percent of pupils, the old design is higher than the acceptable extents, and the new design is higher for 52 and 36.6 percent of pupils than the acceptable extents. In both designs, there is a significant difference between the acceptable minimum and maximum mean in comparison with the sizes used by pupils ($p < 0.001$).

In the old design, the proportion rate of the seat depth of used chairs with the studied sample in order of the size is just 7.9, 8 and 2.1 percent and in the new design, it is 44.6 and 62.8 percent. There is a significant difference between acceptable minimum and maximum mean of the seat depth in comparison to the mentioned sizes ($p < 0.001$).

Regarding the seat width, in the old design, the proportion rate of the chairs to the pupils in the order of size is 45.5, 10.2 and 51.8 percent and in size 1 and 2 of the new design it is 26 and 49.7. There is a significant difference between acceptable minimum and maximum mean of the hip breadth in comparison to the sizes used by the pupils except for the second size of the new design. As for the desk height, in the order of the three sizes, the old design is higher than the acceptable height for 100, 95.4 and 74.3 percent of the pupils and the new de-

sign is proportionate to just 6.4 and 34.6 percent of the pupils. There is a significant difference between acceptable minimum and maximum mean of the desk height in comparison to the sizes used in both designs ($p < 0.001$).

The seat slope in the two designs (old and new) is zero that is conforming to the International Standard Organization limit. In the old design (three sizes) angle of back rest is 90 degrees, that is smaller than the ISO recommended limit but this angle in the new design (two sizes) is 100 degrees, which corresponds to the ISO recommended limit. More information on this section is presented in tables 3 and 4.

Discussion

This study showed that there is no proportion between the measured anthropometric dimensions and the available furniture dimensions. In the old design, seat height and the seat depth exceed the acceptable limits for most pupils. Among the measured dimensions, underneath desk height in the two designs shows more proportion to the pupils which is caused by desk height that is more than acceptable extent for most of the pupils, whereas in size three of the old designs just 4.7 percent of pupils in sitting position, are in contact with the desk and their feet do not move easily and in the new design, in order of size, this number is 1.5 and 3.1 percent. Also too much height of the desk in the old design causes non-conformity of backrest support height with

Table 3. The mean of minimum and maximum acceptable level in comparison with size, and 95% confidence interval, for old and new design of furniture

Type of design	Type of size	Mean and SD		Size	T value		P value		
		Acceptable minimum	Acceptable maximum		Acceptable minimum	Acceptable maximum	Acceptable minimum	Acceptable maximum	
Old design	Size 1	The seat height	28.6(2)	32.99(2.39)	35	-11.9	-43.1	0.001	0.001
		The seat depth	24.89(2.2)	30.8(2.7)	21.6	21.1	47.6	0.001	0.001
		The seat width	26.32(2.91)	31.1(3.44)	30	-17.8	4.59	0.001	0.001
		Height of backrest	25(1.76)	33.44(2.35)	36.9	-94.9	-20.8	0.001	0.001
		Desk height	45.68(2.9)	53.66(3.2)	68	-108.8	-62.8	0.001	0.001
		Underneath desk height	41.1(3.2)	49.6(2.5)	50.6	-4.12	-52.8	0.001	0.001
	Size 2	The seat height	32.2(2.73)	37(3.1)	41.8	84.97	-36.59	0.001	0.001
		The seat depth	27.88(2.5)	34.5(3.11)	24.1	36.54	81.1	0.001	0.001
		The seat width	29.24(3.31)	34.55(3.91)	40.1	-79.4	-34.3	0.001	0.001
		Height of backrest	27.34(2.24)	36.45(2.99)	28.8	-15.77	62	0.001	0.001
		Desk height	50.81(3.92)	59.62(4.47)	69.3	-114.32	-52.2	0.001	0.001
		Underneath desk height	45.57(3.3)	55.64(4.47)	55.3	-71	1.85	0.001	0.001
	Size 3	The seat height	35.75(2.82)	41.1(3.2)	43.4	-37.3	-9.6	0.001	0.06
		The seat depth	30.78(2.79)	38(3.45)	24.4	31.57	54.7	0.001	0.001
		The seat width	31.73(3.4)	37.5(4.1)	36.6	-19.3	3	0.001	0.001
		Height of backrest	29.7(2.3)	39.6(3.1)	28.1	9.58	50.3	0.001	0.003
		Desk height	55.4(4.28)	65.2(4.7)	69.1	-43.93	-11.2	0.001	0.001
		Underneath desk height	49.6(3.68)	61.26(4.7)	54.4	-17.9	20.1	0.001	0.001
New design	Size 1	The seat height	31.31(3)	36(3.45)	36.5	-48.47	-3.92	0.001	0.001
		The seat depth	27.12(2.76)	33.56(3.42)	34	-69.85	-3.57	0.001	0.001
		The seat width	28.49(3.45)	33.67(4)	36	-61	-15.9	0.001	0.001
		Height of backrest	26.76(2.35)	35.68(3.13)	37.7	-130.87	-18	0.001	0.001
		Desk height	49.5(4.31)	58.12(4.94)	66.6	-111.36	-48.32	0.001	0.001
		Underneath desk height	44.45(3.67)	54.11(4.94)	53.5	-69.18	3.5	0.001	0.001
	Size 2	The seat height	35.75(2.82)	41.12(3.25)	40.3	-22.27	3.49	0.001	0.001
		The seat depth	30.78(2.79)	38(3.45)	37.4	-32.74	2.76	0.001	0.001
		The seat width	31.73(3.48)	37.5(4.11)	37	-20.86	1.71	0.001	0.08
		Height of backrest	29.74(2.37)	39.66(3.17)	39.2	-54.89	2	0.001	0.04
		Desk height	55.47(4.28)	65.27(4.7)	69.2	-44.25	-11.53	0.001	0.001
		Underneath desk height	49.6(3.6)	61.26(4.7)	55.5	-22.11	16.92	0.001	0.001

Table 4. Percentages (%) of match, above maximum of acceptable level and below minimum of acceptable level for old and new design of furniture

			The seat height	The seat depth	The seat width	Height of backrest	Desk height	Underneath desk height
Old design	Size 1	Above maximum acceptable level	83.7	0	42.1	90.6	100	57.9
		Match	15.8	7.9	45.5	9.4	0	42.1
		Below minimum acceptable level	0.5	92.1	12.4	0	0	0
	Size 2	Above maximum acceptable level	91.3	0	89.3	0	95.4	50.1
		Match	8.5	8	10.2	74.2	4.6	49.9
		Below minimum acceptable level	0.2	92	0.5	25.8	0	0
	Size 3	Above maximum acceptable level	69.1	0	40.3	0	74.3	10
		Match	30.9	2.1	51.8	26.7	25.7	83.2
		Below minimum acceptable level	0.5	97.9	7.9	73.3	0	4.7
New design	Size 1	Above maximum acceptable level	52	54.2	70.9	68.5	93.6	45
		Match	43.4	44.6	26	31.4	6.4	53.5
		Below minimum acceptable level	4.7	1.1	3	0.1	0	1.5
	Size 2	Above maximum acceptable level	36.6	35.1	43	36.6	65.4	11.5
		Match	59.2	62.8	49.7	63.4	34.6	85.3
		Below minimum acceptable level	4.2	2.1	6.3	0	0	3.1

pupils, so that in size one and two of this design, 90.6 and 95.4 percent of pupils have to use a backrest higher than the acceptable height. In this design, back desk is a backrest for the front desk. In the old design, chair's backrest angle is 90 degrees, but in the new design, it has increased to 100 degrees. With backrest angle increasing, the pressure on back muscles decreases and leaning to a backrest causes distributing the weight of upper part of the body to the backrest and decreases tensions from back and spinal column.¹⁶ While the seat width should conform to students' hip breadth, this study showed that in the old design, in the order of size, 12.4, 0.5 and 7.9 percent of pupils sit next to each other in a pressed position and their activity range is limited.

Compared to old design, in the new design of the available furniture, the conformity rate has relatively improved in all dimensions except the desk height. In this design, the desk height for 93.6 and 66.4 percent of pupils is

higher than the acceptable height. Regarding the obtained results, the seat height is higher than the acceptable height and causes additional pressure on below areas of legs. However, because many of the pupils' desks' heights are more than the acceptable height, they have to sit on the edge of the bench to easily access the desk surface while reading and writing, so they miss the chair backrest and raise their shoulders from the comfort position which causes discomfort and pain in shoulders and the neck.¹⁷

Minimum and maximum calculated dimensions of the furniture increase by age for both sexes. The results of Saarni et al study conducted in 2007 which was done on 74 American students whose age were between 11 and 13 years old, showed that less than 20 percent of students were proportionate to the used furniture dimensions. The seat and desk were too high and chairs were also too deep and only the space under the desk didn't cause prob-

lems for most students which confirm the results of this study.¹⁸

Conclusions

Generally, in the study of the two designs (old and new) of the available furniture, it was revealed that desk height and seat height were higher than the acceptable height for most pupils, whereas seat depth in the old design was short for most pupils. The new design also

conforms to users only in some dimensions, and in less than 20 percent of the studied schools, this design (new) of furniture was used.

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Conflict of Interests

Authors have no conflict of interests.

Authors' Contributions

EH carried out the design and coordinated the study, participated in most of the experiments and prepared the manuscript. ZA provided assistance in collecting data and the design of the study. SMH provided assistance in data analysis. All authors have read and approved the content of the manuscript.

References

1. Pheasant S. Bodyspace: anthropometry, ergonomics and the design of the work. Trans Mououdi MA, Choobineh A. Tehran: Maad Publisher; 2006. p. 105-15. (Persian).
2. Gouvali MK, Boudolos K. Match between school furniture dimensions and children's anthropometry. *Appl Ergon* 2006;37(6):765-73.
3. Knight G, Noyes J. Children's behavior and the design of school furniture. *Ergonomics* 1999;42(5):747-60.
4. Geldhof E, De Clercq D, De Bourdeaudhuij I, Cardon G. Classroom postures of 8-12 year old children. *Ergonomic* 2007;50(10):1571-81.
5. Tunay M, Melemez K. An analysis of biomechanical and anthropometric parameters on classroom furniture design. *Afr J Biotechnol* 2008;7(8):1081-6.
6. Abdoli Ermaki M. *Ergonomics*. Tehran: Omid Majd Publisher; 1994. p. 275-305. (Persian).
7. Panagiotopoulou G, Christoulas K, Papanicolaou A, Mandroukas K. Classroom furniture dimensions and anthropometric measures in primary school. *Appl Ergon* 2004;35(2):121-8.
8. Legg SJ, Pajo K, Sullman M, Marfell-Jones M. Mismatch between classroom furniture dimensions and student characteristics in three New Zealand secondary schools. In: *Proceeding of the 15th Congress of the International Ergonomics Association. Ergonomics for Children in Educational Environments Symposium*, vol. 6; 2003 Aug 24-26; Seoul, Korea. p. 395-7.
9. Hänninen O, Koskelo R. Adjustable table and chairs correct posture and lower muscle tension and pain in high school students. *Proceedings of the XVth Triennial Congress of the International Ergonomics Association and the 7th Joint Conference of Ergonomics Society of Korea/Japan Ergonomics Society*, Volume 6. Safety and Health Miscellaneous Topics; 2003 Aug 24-29; Seoul, Korea. p. 339-42.
10. Molenbroek JF, Kroon-Ramaekers YM, Snijders CJ. Revision of the design of a standard for the dimensions of school furniture. *Ergonomics* 2003;46(7):681-94.
11. Chung JW, Wong TK. Anthropometric evaluation for primary school furniture design. *Ergonomics* 2007;50(3):323-34.
12. Koskelo R, Vuorikari K, Hänninen O. Sitting and standing postures are corrected by adjustable furniture with lowered muscle tension in high-school students. *Ergonomics* 2007;50(10):1643-56.
13. Mououdi MA, Choobineh AR. Static anthropometric characteristics of students' age range six-11 in Mazandaran province/Iran and school furniture design based on ergonomics principles. *Appl Ergon* 1997;28(2):145-7.
14. Varmazyar S, Ghalehnoei M, Amani Z, Mohammadi F, Eivazlou T, Inanlou F, et al. Design of school furniture based on anthropometric dimensions of female high school students in Qazvin, Iran in 2007. *J Qom Uni Med Sci* 2008;2(3):39-46. (Persian).

15. García-Acosta G, Lange-Morales K. Definition of sizes for the design of school furniture for Bogotá schools based on anthropometric criteria. *Ergonomics* 2007;50(10):1626-42.
16. Kaya MD, Hasiloglu AS, Bayramoglu M, Yesilyurt H, Ozok AF. A new approach to estimate anthropometric measurement by adaptive Neuro-fuzzy interference system. *Int J Ind Ergon* 2003;32(2):105-14.
17. McCormick EJ, Sanders MS. *Human factors in engineering and design*. 6th ed. Boston: McGraw-Hill Inc.; 1987. p. 31.
18. Saarni L, Nygård CH, Kaukiainen A, Rimpelä A. Are the desks and chairs at school appropriate? *Ergonomics* 2007;50(10):1561-70.