Endüstri Mühendisliği Dergisi
Cilt: 17 Sayı: 2 Sayfa: (2-8)

Makina Mühendisleri Odası

ANTHROPOMETRIC EVALUATION OF KINDERGARTEN CHILDREN IN TURKEY

Önder BARLI[1*], Erkan AYDINTAN[2], Serpil ÜSTÜN[3], Reyhan MİDİLLİ[4], Derya ELMALI[4], Süleyman ÖZGEN[2], Tarık GEDİK[5]

[1]*Ataturk University, Faculty of Economics & Administrative Sciences*
[2]*Karadeniz Technical University, Department of Interior Design*
[3]*Karadeniz Technical University, Department of Mechanical Engineering*
[4]*Karadeniz Technical University, Department of Architecture*
[5]*Karadeniz Technical University, Department of Forest Industry Engineering*

ÖZET

Bu makalede, Trabzon/Türkiye'de anaokuluna gitmekte olan oğlan ve kız çocuklarına ilişkin yapılan antropometrik bir çalışmanın sonuçları verilmektedir. Bu çocukların ortalama olarak yaşları 6 dır. Araştırmanın ilk aşamasında 144 kız ve 144 oğlandan 18 vücut ölçüsü alınmıştır. Alınan ölçüler milimetre cinsinden olup bazı istatistiksel metotlar kullanılarak analiz edilmişlerdir. Bu istatistik teknikler hem ortalama, standart sapma, yüzdelikler gibi tanımlayıcı istatistikleri hem de bazı parametrik testleri kapsamaktadır. Cinsiyetler arasında herhangi bir farklılığın olup olmadığının anlaşılması amacıyla, alınan ölçüler karşılaştırılmıştır. Ölçümü yapılan bu 18 parametrenin, okul mobilyalarının ve diğer ekipmanlarının kullanımı sırasında, kötü tasarım yüzünden meydana gelebilecek kassal, görsel ve devinimsel gibi çeşitli ergonomik problemlerin çözümünde gerekli olduğu düşünülmektedir.

Anahtar Kelimeler: Antropometri; Anaokulu çocukları; Türkiye

ABSTRACT

In this paper, the results of an anthropometrical study conducted on male and female children in Trabzon province/Turkey are presented. The children have an average age of 6 years. During the first phase of the investigation, 18 body dimensions were taken from l44 boys and 144 girls. All the data were taken in millimeters and analyzed using some statistical methods. The statistics were included both descriptive statistics such as means, standard deviations, percentiles and some parametric tests. The anthropometrical measurements were compared to investigate sexual differences between body dimensions. It is considered that the 18 parameters are necessary for the design of school furniture and equipment in order to minimize musculoskeletal, visual, and circulatory problems resulting from using badly designed furniture and equipments.

Keywords: Anthropometry; Kindergarten children; Turkey

* Corresponding Author

INTRODUCTION

Anthropometrical measurements of the human body have been developed for various reasons since early times of history. Only since the Second World War, however, have such data been developed essentially for design of equipment and workplaces (Bolstad et al., 2001). The aim is to eliminate harmful postures and to minimize the design imposed stresses on the user. At the same time small changes, if made, to the required physical dimensions of the workspace can have considerable impact on worker productivity and occupational safety and health. Therefore, the user characteristics and specifically the structural anthropometrics dimensions should be known for design of an effective workstation (Das and Kozey, 1999).

It is necessary to know the body dimensions of the potential user while designing products. That is important for service sectors such as schools, hotels and banks as well as production and manufacturing sectors. Accidents may occur due to incorrect product dimensions and sizes that do not meet the human dimensional requirements. Musculokeletal, visual and circulatory health problems are the expected results of this situation (Prado-Leon, 2001).

It is observed that a few amount of the Turkish population seeks medical attention for back problems at some time in their lives. Contrary to what one might assume, back problems are not confined to the adult population. A severe number of school children and adolescents would be estimated to have regular bouts of back, neck, and headache pain.

Pre-school children and teenagers are expected to sit about 30% and 78% of their time during school, respectively. Harper et al. (2002) noted the importance of furniture specifically designed for a child's body proportions and recommended different sitting postures for different activities. The detrimental effects of improper classroom furniture on the spine have been known for a long time (Zacharkow, 1998). Current research in the area of school furniture design has predominantly been conducted in the Scandinavian countries. The trend is also spreading in Germany, France, and Switzerland (Mandal, 1982).

It is known that there are serious ergonomics problems in schools in Turkey that can be related to a lack of reliable anthropometrical data and its application. The main objective of this research is to determine reliable and accurate structural anthropometrical measurements for male and female children to use in the product design process.

METHODS

The experimental method will be described under the following sub-headings: (1) Subjects, (2) Dimensions measured, (3) Measuring equipment, (4) Measuring Procedure, (5) Statistics.

Subjects

Data were obtained from measurements on 288 healthy children from kindergartens in Trabzon. Half of them are females. The number of subjects was determined statistically. 44 numbers kindergartens were determined which have been active during the year 2002. The total number of children was about 1350 in these kindergartens. Using a formula, (see Özdamar, 2001 p. 257) 300 sample size was calculated for Z=0.05, P/Q=50% and D/H=5% parameters. There were about 300 children in the seven kindergartens that were randomly selected. Finally, measurements of 288 children were deemed valid for the analysis of this research.

All of the kindergartens are in around the city of Trabzon. All subjects voluntarily participated in all aspects of this study. Both subjects and kindergartens were selected randomly (Yadav et al., 1997; Prado-Leon et al., 2001; Bolstad et al., 2001). Measurements were done on 6 years old children attending seven different kindergartens.

Dimensions measured

In this research, 18 anthropometrical dimensions were measured for both males and females: Nine of the dimensions were related to the standing position and nine to the sitting position (Table 1, Fig. 1 and 2), as mentioned in similar researches (Jarosz, 1999; Das and Kozey, 1999).

The subject postures and the definitions of each anthropometrical parameter were based on standard procedures as used by Hertzberg, 1968. The dimensions measured were all named and numbered according to CEN standard EN 979 "Basic list of definitions of human body measurements for technical design" (identical with ISO standard 7250:1996) (Bolstad et al., 2001).

Measurements were taken from the right side of the body with the subject standing in a relaxed condition as proposed by Mona and Latif, 2001. Eventhough no statistical difference was found between measurements on either side of the body.

Table 1. Anthropometrical Characteristics Measured in the Standing and Sitting Position

Position	
Standing	Sitting
1. Stature	10. Stature
2. Maximum vertical reach	11. Eye height
3. Eye height	12. Elbow height
4. Elbow height	13. Hip breadth
5. Forward elbow reach	14. One calf thickness
6. Forward arm reach	15. Two calf thickness
7. Shoulder breadth	16. Buttock- calf depth
8. Elbow to elbow breadth	17. Buttock- knee depth
9. Waist depth	18. Sitting height

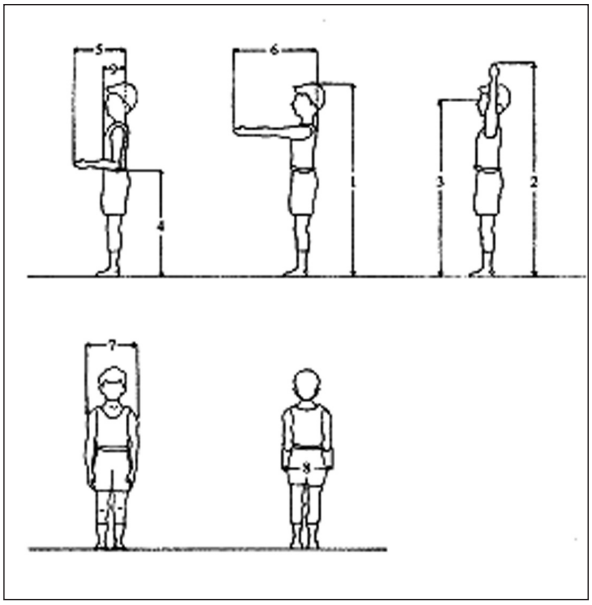

Fig.1. *Anthropometric Characteristics Measured in the Standing Position*

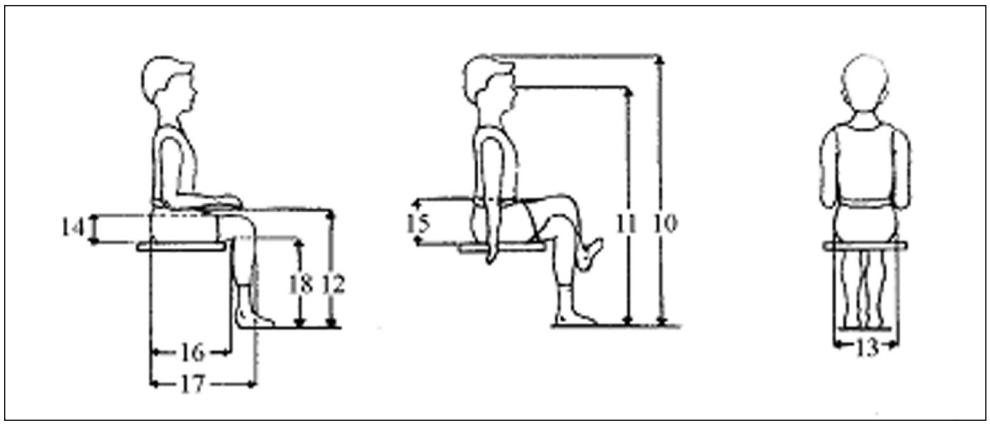

Fig.2. *Anthropometric Characteristics Measured in the Sitting Position*

Measuring equipment

Forward arm reach was measured using a tape measure according to the method of Lohman et al., (1988). Small, slightly modified sliding calipers (Mitotoyo Co., Japan) and a portable chair of adjustable height were also used to measure the sitting dimensions; Height and depth were measured using a portable adjustable tape measure (Henry et al., 2001).

Measuring procedure

In this research, measurements were taken on 288 children during the two-month-period. Measurements were taken during the spring of 2002 by two groups of researchers, each having an architect, interior designer, and industrial and mechanical engineers. The researchers were trained in anthropometrical techniques and checked for consistency in their procedures. Along with the measurements, general information such as age, sex and name was recorded together with the name of the kindergartens.

The subjects were measured in standing and sitting positions (Harper et al., 2002). And they were wearing light (indoor) clothes. In the sitting position, the knee and hip angles were controlled to be 90°. Subjects who were unable to extend their arms at right angles to their body and those with extensive curvature of the spine were excluded from the measurements (McConville and Laubach, 1978; Hertzberg, 1968).

Statistics

All the data were taken in milimeters, entered into a computer and analyzed using the statistical package for the social sciences (SPSS v.11) (Henry et al., 2001; Harper et al., 2002; Albala et al., 1997; SPSS, 1999).

Prior to any statistical analysis, the Kolmogorov-smirnov test for normality was performed for all dimensions to ensure that the data represented a normal distribution (Table 2) (Bolstad et al., 2001; Özdamar, 2001). An ln transformation was employed for the

Table 2. The results of Kolmogorov-Smirnov Test

Variable	Groups	K. S. Z	Sig. (2-tail)	Variable	Groups	K. S. Z	Sig. (2-tail)
Stature	1	.364	.999	Sitting Stature	1	.687	.733
	2	.623	.833		2	.647	.797
Max. Vertical Reach	1	.487	.972	Eye Height	1	.596	.870
	2	.829	.498		2	.538	.934
Eye Height	1	.467	.981	Elbow Height	1	.349	1.000
	2	.916	.371		2	.820	.513
Elbow Height	1	.771	.593	Hip Breadth	1	1.270	.079
	2	.743	.639		2	1.415	.042
Forward Elbow Reach	1	.790	.561	One Calf Thickness	1	1.421	.035
	2	.874	.430		2	1.418	.088
Forward Arm Reach	1	.580	.889	Two Calf Thickness	1	1.266	.081
	2	.758	.614		2	.954	.322
Shoulder Breadth	1	1.079	.195	Buttock-calf Depth	1	.702	.707
	2	1.297	.069		2	.765	.602
Elbow to Elbow Breadth	1	.676	.751	Buttock-knee Depth	1	.546	.927
	2	.850	.466		2	.691	.727.
Waist Depth	1	.893	.403	Sitting Height	1	.760	.611
	2	1.077	.196		2	.771	.592
				One Cal. Thic. Trans.	1	1.248	.089
					2	1.418	.088

1: Female
2: Male

data that did not show a normal distribution. Then, some descriptive statistics such as means, standard deviations and percentiles were calculated separately for all males and all females. At the same time, based on these values, the 1st, 5th, 50th, 95th and 99th percentiles were calculated.

Statistical comparisons between the mean dimensions of the males and females were also performed (Table 3 and 4) using a series of the Independent student sample *t*-test with equal n, and a critical value of 0.05 (Das and Kozey, 1999; Joines and Sommerich, 2001; Bolstad *et* al., 2001; Jarosz, 1999; Özdamar, 2001).

Table 3. Percentiles-females and Males, Total Population (cm)

Dimension	Group	Mean	St. Dev.	1 %	5 %	50 %	95 %	99 %
Stature	1	112,99	4,77	101,45	104,63	113,00	121,00	125,49
	2	114,89	5,21	103,00	107,13	114,50	124,28	128,77
Max. Vertical Reach	1	137,80	7,37	121,23	125,20	138,00	150,48	157,05
	2	140,39	7,69	123,52	128,60	139,20	155,68	160,03
Eye Height	1	100,73	4,86	88,790	93,30	101,00	108,15	114,70
	2	102,52	5,14	90,83	94,20	102,15	112,65	116,08
Elbow Height	1	66,43	3,62	58,62	60,38	66,40	73,20	77,55
	2	67,00	3,82	59,39	60,88	66,85	74,33	77,30
Forward Elbow Reach	1	40,90	2,61	33,45	36,15	40,95	44,75	45,61
	2	41,20	3,19	32,98	35,13	41,20	46,83	48,66
Forward Arm Reach	1	54,27	3,28	47,11	49,30	54,15	59,83	65,70
	2	55,49	3,60	46,45	50,15	55,05	62,10	66,36
Shoulder Breadth	1	28,33	1,71	25,34	25,93	28,00	31,00	34,42
	2	29,06	2,28	24,39	26,03	28,95	33,70	36,40
Elbow to Elbow Breadth	1	29,70	2,19	25,23	26,13	29,65	33,65	35,78
	2	30,72	2,74	25,64	26,85	30,40	35,98	38,83
Waist Depth.	1	15,85	1,34	12,99	14,00	15,65	18,35	19,55
	2	16,21	1,65	11,95	14,15	16,00	19,50	20,89
Sitting Stature	1	84,58	3,44	75,62	78,63	84,50	90,13	92,25
	2	85,53	4,15	76,20	78,88	85,55	92,50	96,49
Eye Height	1	73,08	3,55	63,31	66,93	72,90	78,90	80,31
	2	73,82	3,82	64,40	67,83	73,80	79,80	84,52
Elbow Height	1	40,57	2,26	35,79	36,65	40,60	44,15	47,66
	2	40,44	2,87	34,45	35,93	40,35	45,53	48,88
Hip Breadth	1	22,12	1,73	19,40	20,00	21,80	25,50	28,22
	2	22,85	2,61	19,75	20,15	22,55	27,45	30,26
One Calf Thickness	1	9,87	1,33	7,60	8,03	9,60	12,45	14,78
	2	9,79	1,67	7,30	7,53	9,50	13,00	14,74
Two Calf Thickness	1	15,97	2,36	10,59	12,50	15,50	21,33	22,55
	2	17,13	2,93	11,45	12,93	16,90	22,50	26,15
Buttock-calf Depth	1	33,47	2,06	28,81	30,13	33,40	37,28	39,12
	2	33,27	2,21	28,03	30,13	33,10	37,20	38,73
Buttock-knee Depth	1	38,30	2,16	34,09	35,00	38,20	42,25	43,73
	2	38,44	2,32	33,53	34,78	38,15	43,00	44,97
Sitting Height	1	29,41	1,52	25,89	27,10	29,30	32,30	33,50
	2	29,38	1,41	26,35	26,73	29,40	31,88	32,73

1: Female

2: Male

Table 4. The Values of the T-Test Between the Female and Male Groups

Dimension	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tail)	Std. Er. Differ.	95% Confidence	
							Lower	Upper
Stature	1.007	.316	-3.225	286	.001	.5891	-3.0594	-.7406
Max Vertical Reach	.221	.639	-2.919	286	.004	.8878	-4.3384	-.8436
Eye Height	.222	.638	-3.077	286	.002	.5882	-2.9675	-.6519
Elbow Height	.304	.582	-1.315	286	.190	.4384	-1.4393	.2865
Forward Elbow Reach	1.767	.185	-.871	286	.384	.3436	-.9756	.3770
Forward Arm Reach	1.379	.241	-3.003	286	.003	.4056	-2.0164	-.4197
Shoulder Breadth	5.544	.019	-3.109	286	.002	.2370	-1.2033	-.2703
Elbow-to-elbow Breadth	4.034	.046	-3.498	286	.001	.2920	-1.5963	-.4468
Waist Depth	4.192	.042	-2.055	286	.041	.1771	-.7124	-1.5E-02
Sitting Stature	6.598	.011	-2.157	286	.032	.4492	-1.8529	-8.E-02
Eye Height	.663	.416	-1.688	286	.092	.4347	-1.5897	.1216
Elbow Height	7.024	.008	.443	286	.658	.3040	-.4636	.7331
Hip Breadth	4.774	.030	-3.769	286	.000	.2294	-1.3160	-.4131
One Ca. Thic. Trans	7.871	.005	.051	286	.959	.1760	-.3373	.3553
Two Calf Thickness	7.352	.007	-3.692	286	.000	.3137	-1.7759	-.5408
Buttock-calf Depth	1.692	.194	.793	286	.428	.2521	-.2962	.6962
Buttock-knee Depth	.504	.478	-.497	286	.619	.2640	-.6508	.3883
Sitting Height	1.395	.239	.177	286	.860	.1727	-.3093	.3704

RESULTS

Anthropometrical characteristics of male and female students aged 6 were measured separately for the standing and sitting positions (Table 1). Table 1 comprises two groups of characteristics:

Static (no 1, 3, 4, 7-13, 16-18)

Dynamic (no 2, 5, 6, 14, 15)

DISCUSSION

Parametric data should resemble a normal distribution for using the parametric statistics techniques (Statistica, 2002). Thus, first the data set was checked for normality. The Kolmogorov-smirnov test indicated that the data resembled a normal distribution except for one characteristic of female group, one calf thickness. Therefore an ln transformation on this variable was conducted. After that descriptive statistics (arithmetic mean, standard deviation, 1st, 5th, 50th, 95th and 99th percentiles) were calculated for each characteristic for the pooled male and female populations (Table 3).

As seen in Table 3, there were significant differences in arithmetic means of most of the analyzed characteristics between the male and female groups. But the vertical reach and forward arm reach dimensions did not show any significant difference between the two groups.

Independent student sample t-test was applied to define the differences among the mean values for the two groups displayed in the Table 4. According to the test, there were significant differences in stature, max vertical reach, eye height, forward arm reach, shoulder breadth, elbow to elbow breadth, waist depth, stature sitting, hip breadth sitting, two calf thickness. On the other hand there were no significant differences among the other characteristics of two groups.

CONCLUSION

It is known that there are a lot of ergonomic problems in the schools in Turkey. Such a study can improve effectiveness of the schools and minimizes health problems there. It is often argued from an economic and ergonomic point of view that ergonomic

considerations should be integrated into the planning and production processes, but it is seldom the case in practice in Turkey. On the other hand, tools for establishing this integration are accessible. Thus, the set of anthropometrical data obtained should be used for the design or adaptation of interior design and furnishing as well as the design of places where we live or work.

This study is putting forward the anthropometrical characteristics of the kindergarten children. It is the first study that has been managed in Turkey and it is accepted that the continuity of this kind of studies is beneficial for the researches in anthropometry and product design.

By increasing the number of anthropometrical characteristics taken from children, the data would be used in industrial and social life such as furnishing, textile products and school. It would also put forward the anthropometrical differences of children living in different regions in Turkey. Finally, because of differences in measures of the human body, this kind of study would be repeated periodically.

Acknowledgements

We thank all of the children who participated in this study. In addition, we thank all managers and employees of the schools for their support in this research.

REFERENCES

1. Albala, C., G. Salazar, M. Yanez, et al. 1997. Validation Of An Anthropometric Model For Total Body Water Determination in The Elderly, Nutrition Research, Vol. 17, No. 1, pp. 1-7.
2. Bolstad, G., B. Benum and A. Rokne, 2001. Anthropometry of Norwegian light industry and office workers, Applied Ergonomics, Vol. 32, pp. 239-246.
3. Das, B. and J.W. Kozey, 1999. Structural anthropometric measurements for wheelchair mobile adults, Applied Ergonomics, Vol. 30, pp. 385-390.
4. Gould, S. J., The Mismeasure of Man Norton and Co: 1993
5. Harper,K., D. Mallin, N. Marcus, et al. May 2002. Ergonomic Evaluation of the KinderZeat Child Seat in a Preschool Setting, Class Project Report, Cornell University, pp. 1-18.
6. Henry, C. J., C. Varakamin, J. W. Gandy and S. Ulijaszek, 2001. Anthropometry of two contrasting populations of Thai elderly living in a rural setting, Archives of Gerontology and Geriatrics,Vol. 33, pp. 255–263.
7. Hertzberg, H.T.E., 1968. The conference on standardization of anthropometric techniques and terminology. Am. J. Phys. Anthropol. 28, 1-16.
8. Jarosz, E., 1999. Anthropometry of elderly women in Poland: dimensions for design, International Journal of Industrial Ergonomics, Vol. 25, pp. 203-213.
9. Joines S.M.B. and C.M. Sommerich, 2001. Comparison of self-assessment and partnered-assessment as cost-effective alternative methods for office workstation evaluation, International Journal of Industrial Ergonomics, Vol. 28, pp. 327–340.
10. Lohman, T.G., Roche, A.F., Martorell, R., 1988. Anthropometric Standardization Reference Manual. Human Kinetic Books, Champaign, IL.
11. Mandal, A., 1982. The correct height of school furniture, Human Factors, 24:257– 69.
12. McConville, J.T., Laubach, L.L., 1978. Anthropometry. In: Churchill, E., Laubach, L.L., McConville, J.T., Tebetts, I. (Eds.), Anthropometric Source Book, Vol. I: Anthropometry for Designers, NASA National Aeronautics and Space Administration, National Technical Information Service, Springfield, "VA, pp. III/1-III/ 105.
13. Mona, A. and A. Latif, 2001. Estimation of body fat from skinfold thickness, Computer Methods and Programs in Biomedicine, Vol. 65, pp. 201–206.
14. Özdamar, K., August 2001. SPSS ile Biyo İstatistik, No. 30.
15. Prado-Leon, L. R., R Avila-Chaurand and E. L. Gonzalez-Munoz, 2001. Anthropometric study of Mexican primary school children, Applied Ergonomics, Vol. 32, pp. 339-345.
16. SPSS, Statistical Package For Social Sciences, Release 10.0.1, SPSS Inc., 1999.
17. STATISTICA, Statistical Package, StatSoft Inc. 1984-2002.
18. Yadav, R., V.K. Tewari and N. Prasad, 1997. Anthropometric data of indian farm workers – a module analysis, Applied Ergonomics,Vol. 28, No. 1, pp. 69-71.
19. Zacharkow, D., 1988. Posture: sitting, chair design and exercise. Springfield, IL: CC Thomas.