

# A Research on The Suitability of Desk Ergonomics of a Foundation University for Anthropometric Measurements of Students and its Impact on Their Life Quality

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## ABSTRACT

**Purpose:** Sitting for a long time is considered to be one of the most important disease risks. Therefore, individual-specific arrangements in the early period can prevent these diseases. This study was aimed to assess the suitability of school desk and chair for Turkish population with current anthropometric measurements and find out the impact of this on the same participants' life quality.

**Method:** The students of the School of Health Science (N=153) made up the sample for this study. 14 different anthropometric measurements were taken from the participants and they were required to fill in the WHOQOL-Bref Life Quality Scale for the last month in the study.

**Result:** Statistically no significant difference was determined in regards of general and sub-parameters of life quality points such as physical and environmental points between sample female (n=81) and male (n=72) population ( $p>0.05$ ). Some fit and unfit measurements for desk dimensions were determined when anthropometric measurements of desk dimensions were analyzed minimally and maximally (5-95%) in terms of gender.

**Conclusion:** In this study musculoskeletal disorders owing to the long term use of ergonomically unsuitable desks by determining fit and unfit measurements in desk dimensions and the effect of this on life quality are explained. Also norm values for new furniture designs were determined by calculating anthropometric measurements that must be updated termly for the continuously changing population.

**Keywords:** Ergonomics, life quality, anthropometry

## INTRODUCTION

The seating elements consist of a desk and chair. The aims of seating ergonomics is to encourage upright sitting posture that decreases the loading on intervertebral discs and the back. Improperly designed and unfitted desks and chairs can result in an unbalanced and kyphotic posture of spine and requires more muscle control to maintain upright posture and sitting position (1). This study aims to assess the suitability of school chairs and desks for Turkish population with the help of today's anthropometric measurements and also find out the effect of this on our populations life quality.

The use of furniture that is also important for modern man dates back to the Stone Age and man used to form useful chairs and tables by gouging stones and rocks at this age. In ancient civilizations, chair was the first form of furniture to symbolize status, kingdom and authority. Especially in old Egypt

archeologists explored first forms of furniture, designed and used by ancient civilizations (2).

Furniture designs changed in the meantime and with the mass production, brought out by the Industrial Revolution in the mid 19th century, chairs and tables started to be produced in large quantities in various dimensions and forms (2).

Even though adjustability was the main criteria for many furniture designs, it was thought that there were more than two dimensions to adjust in the early 1960's but to determine the most suitable dimension for users became a matter of discussion (3).

Measurements of chairs and tables are taken with anthropometric measurements especially in mass production, anthropometric statistics are collected and designs are made according to these statistics.

With the production of modern furniture, in the early 1990 s, mass production of chairs with different forms and dimensions started to be produced based on available anthropometric data specifically by designers (4).

Anthropometry, also used in furniture design, is a method which describes body shape numerically and evaluates body composition. The technique of anthropometry is quite a useful and important method, used in ergonomics field to determine diseases and evaluate the studies of population (5).

Ergonomy is a multi-disciplinary science that underlines the basic rules of work productivity and man-machine-environment harmony against physiological and psychosocial stresses caused by the effect of risky factors of workplace using anatomic and anthropometric characteristics of man (6).

The raw material of ergonomics, whose goal is to improve work efficiency by the adaptation of work and environment to the individual and decreasing the wearing out of individuals so than ergonomics takes place in the design of all the tools used by man and where there is man (7).

People should use their body comfortably in their daily lives. This is only possible with the suitability of the tools, equipment and decoration elements for the anthropometric measurements of man. The mental and physical comfort of the user of the furniture contributes to the success of man (8). A great deal of research on long-term sitting in workplace was done and some design criteria, especially for chairs and tables in computer-work places, were formed. Unfortunately, little or no interest has been shown to the design of school furniture until recently (9).

The use of school furniture, produced without considering ergonomic rules and standards has been shown to lead to the high incidence of students facing musculoskeletal problems such as neck pain, back pain, waist pain and some curving caused by long-term sitting in wrong positions, especially in the period of fast

growing (10). This may culminate in poor academic performance by affecting students' concentration, their health and special abilities.

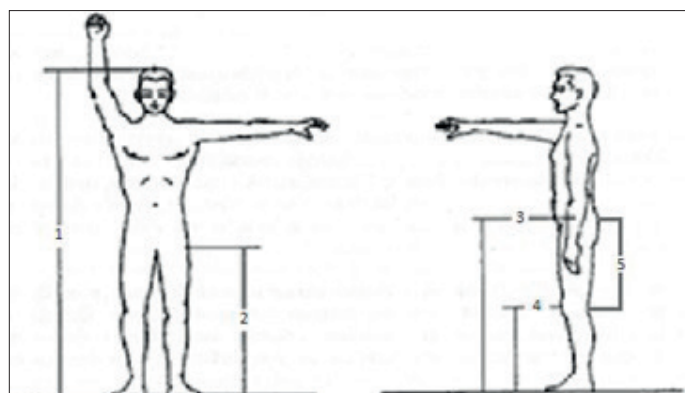
A study showed that the production of tables and benches in Turkey was based on either the data from British or German students' anthropometric measurements or even based on no data about anthropometric measurements (8).

## METHODS

The students of School of Health Science from a foundation university made up the sample size. The Formula  $N = \frac{(0.98)^2}{(d)^2}$  was used to determine the number of sample participants (11) and with the 80% proportion of reliability, the measurements were taken from a total of 153 participants. Ethical approval of our study was given by Ethics committee of the Istanbul Gelişim University (Protocol no: 2 018-17-2).

The studies inclusion criteria are: be a student, have no job, between 18-25 ages; the exclusion criteria are: not have any neurological and muscular disease. The anthropometric measurements were taken in a class setting in two different positions, one sitting and another standing, by two physiotherapists using Baseline tape measure. A total of 14 sub-parameters measurements were analyzed (Diagram 1-2).

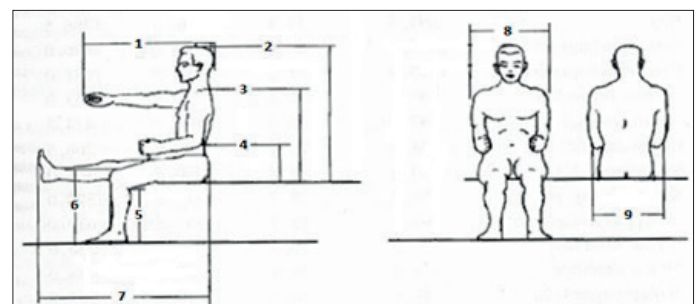
A digital scale was used to measure the weight of participants. Each student participating in this study was asked to complete the WHOQOL Bref Quality of Life Scale and was informed in advance about how to complete the questionnaire. The WHOQOL (The World Health Organization Quality of Life) Bref Quality of Life Scale is a quality-of-life questionnaire that includes questions that participants should answer to assess the quality of life of the last month. The validity and reliability of the Turkish version was made by Eser et al. Turkish version consists of 27 questions. The survey evaluates the 5 parameters; environmental health, physical



**Diagram 1.** The static anthropometric measurements taken standing

**Dimensions Measured Standing**

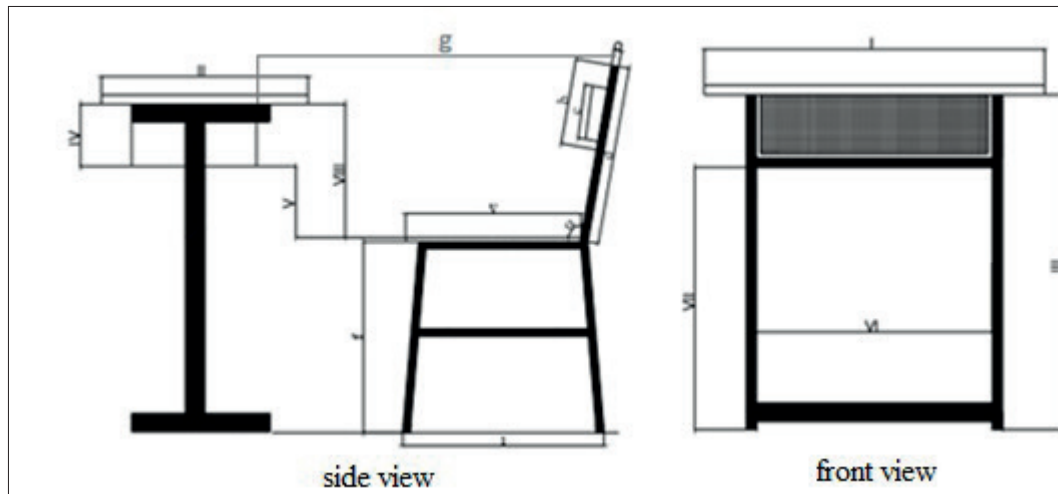
- |                  |   |
|------------------|---|
| 1 Head Height    | 4 Knee Height                             |
| 2 Buttock Height | 5 Buttock-Knee Distance=(Leg-Knee) Height |
| 3 Leg Height     |   |



**Diagram 2.** The static anthropometric measurements taken sitting

**Dimensions Measured Sitting**

- |                      |                       |
|----------------------|-----------------------|
| 1 Forward Grip Reach | 6 Knee Height         |
| 2 Upper-Part Height  | 7 Buttock-Heel Length |
| 3 Shoulder Height    | 8 Shoulder Width      |
| 4 Waist Height       | 9 Width Between Elbow |
| 5 Popliteal Height   |                       |



**Picture 1.** Basic dimensions and view of the desks from two different directions



**Picture 2.** View of the desks from two different directions

health, general health status, psychological, social relations. The parameters range from 4–20. The points are increased the quality of life is increasing (12, 13).

The type of the desks of all classrooms in the School of Health Science of the University is the same and, as is seen below, each desk is measured with the same type measure by the same two persons and average values were calculated for each measurement (Picture 1–2).

#### Statistical Analysis

SPSS 25 Package Programme was used for the statistical analysis of the study. Average, Standard deviation, 5%, 95% values were calculated according to sex variable for anthropometric measurements. Independent Sample t Test was used for the Life Quality Scale. The correlation of anthropometric measurements and life quality scale was done with the Pearson Correlation Analysis.

## RESULTS

When the demographic data of the participants was analyzed, in terms of sex, females constituted 52.9% (N=81), males constituted 47.1% (N=72). BMI for males was assessed as Min (19), Max (37), Mean (23.76±3.35), and for females as Min (17), Max (29), Mean (21.10±2.57). The height was measured for males as Min (163), Max (190), Mean (178.86±5.73) and for females Min (150), Max (183) and Mean (164.42±5.941). The age average for males was defined as 21.33±0.96 and for females as 21.01±0.85.

Dimensions of desks are shown in unit of cm in Table 1. Seventeen different criteria for desks and tables were assessed. The Min., Max., Mean, Standard Deviation with (5–95%) values from anthropometric measurements of the participants according to their sex are shown in Table 2 and Table 3.

As shown as in Table 4; general health point means for male 95.8642, for female 98.2778; physical health point means for male 70.0722, for female 69.5815 and environmental health point means for male 65.1944, for female 64.3111 was found. There is no statistically significant difference between females and males in all health points' means ( $p>0.05$ ) (Table 4).

According to the correlation table for life quality scale points and the data from measurement of males, a weaker correlation was determined between maximum forward grip reach and general health point ( $p=0.022$ ) and physical health point in terms of knee height ( $p=0.001$ ) (Table 5).

According to the correlation table from life quality scale points and data from the measurements of females, it was determined that there is a weak correlation between shoulder width and environmental health point ( $p=0.021$ ) and also between buttock-knee distance and general health point ( $p=0.020$ ), physical health point ( $p=0.038$ ) and environmental health point ( $p=0.011$ ) (Table 6).

## DISCUSSION

Gouvali et al. point out that very long desks aren't suitable for students as students choose more than 25 degree flexion and more than 20 degree abduction position at shoulder joint in order to support their elbows and this resulting in faster fatigue in upper extremity muscles (14). Desk Length as shown as I in table 1, was measured as 48 cm in our study. The main criteria here was Shoulder Width of students. Desk length for male students was assessed as 61.46 cm for 95% value. When these data were considered, desk length for male students was found out to be out of average values and unsuitable ergonomically. When desk length for females was considered, shoulder width was measured as 53.39 cm for the population value of 95% and thus, regarded as unsuitable. Especially students in crowded classrooms will have to sit rotationally or enhance body flexion angle to compensate this situation.

The Desk Width as shown as II in table 1, was determined as 36 cm in the study. The main criteria considered for the suitability of desk width was forward grip reach. In terms of reachability, 68.95 cm for min 5% value is to be considered for male students and thus, desk width can be said to make no matter. As for female students'

**Table 1.**Desk Dimensions

Dimensions		(cm)	Dimensions		(cm)
I	Desk Length	48	a	Metal Parts Thickness	3
II	Desk Width	36	b	Top Point of Seating-Row Distance	26
III	Desk Height	70	c	Seat Back Width	21
IV	Row Height	19	d	Top Point of Seating-Seat Surface Distance	34
V	Row-Seat Surface Distance	7	f	Seat Surface Height	41
VI	Iron Parts of Under Desk Width	43	i	Seating Part Side Width	37
VII	Row Height from The Ground	48	v	Seat Surface Length	38
VIII	Desk Surface -Seat Surface Distance	26	α	Seat Back Slope Angle	90
			g	Seat Back - Row Distance	51

**Table 2.**Statistical Data from Anthropometric Measurements of Males (cm)

Males	Minimum	Maximum	Mean	Standard Deviation	5%	95%
Upper Part Height	63	104	92,25	6,441	79,63	104,87
Shoulder Height	54	69	61,06	3,202	54,78	67,33
Waist Height	17	38	24,85	5,009	15,03	34,66
Forward Grip Reach	67	93	81,72	6,516	68,95	94,49
Popliteal Height	40	59	46,43	3,463	39,64	53,22
Knee Height	47	62	55,69	3,240	49,34	62,04
Buttock-Heel Length	90	120	102,33	6,505	89,58	115,08
Shoulder Width	34	64	49,79	5,955	38,12	61,46
Width Between Elbows	34	72	50,13	6,618	37,15	63,10
Buttock-Knee Distance	37	59	48,0139	5,07824	38,06	57,97

**Table 3.** Statistical Data from Anthropometric Measurements of Females (cm)

Females	Minimum	Maximum	Mean	Standard Deviation	%5	%95
Upper Part Height	65	100	84,93	5,972	73,22	96,63
Shoulder Height	45	71	57,23	3,789	49,81	64,66
Waist Height	16	38	23,57	4,330	15,08	32,05
Forward Grip Reach	62	90	75,90	6,008	64,13	87,68
Popliteal Height	37	49	43,21	2,558	38,20	48,22
Knee Height	42	59	51,27	3,439	44,53	58,01
Buttock-Heel Length	80	116	94,59	6,948	80,98	108,21
Shoulder Width	34	57	43,57	5,010	33,75	53,39
Width Between Elbows	29	65	43,02	6,344	30,59	55,46
Buttock-Knee Distance	33	61	46,66	6,762	33,41	59,92



**Table 4.** The Relations Between Quality Of Life And Gender Variables

	Gender	N	Mean	Standard Deviation	t	Df	p value
General Health Point	Female	81	95,8642	11,59284	1,222	151	,224
	Male	72	98,2778	12,83725			
Physical Health Point	Female	81	69,5815	13,18958	,203	151	,839
	Male	72	70,0722	16,64617			
Environmental Health Point	Female	81	64,3111	13,27491	,382	151	,703
	Male	72	65,1944	15,33023			

Independent Sample T Test

**Table 5.** Life Quality Scale and Anthropometric Measurement Correlation (male)

		Forward Grip Reach	Popliteal Height	Knee Height	Shoulder Width	Buttock-Knee Distance
General Health Point	Pearson Correlation	,270	-,090	,208	,003	-,090
	P value	,022*	,451	,079	,980	,452
Physical Health Point	Pearson Correlation	,255	,005	,394	,096	-,192
	P value	,031*	,966	,001**	,421	,106
Environmental Health Point	Pearson Correlation	,194	-,036	,187	-,041	,037
	P value	,102	,765	,117	,734	,760

\*\*Correlation is significant at the 0.01 level.

\*Correlation is significant at the 0.05 level.

**Table 6.** Life Quality Scale and Anthropometric Measurement Correlation (female)

		Forward Grip Reach	Popliteal Height	Knee Height	Shoulder Width	Buttock-Knee Distance
General Health Point	Pearson Correlation	,076	,063	-,108	,215	,258
	P value	,498	,577	,335	,054	,020*
Physical Health Point	Pearson Correlation	,015	,043	-,103	,039	,232
	P value	,896	,702	,360	,730	,038*
Environmental Health Point	Pearson Correlation	,101	,015	-,094	,257	,281
	P value	,369	,897	,405	,021*	,011*

\*\* Correlation is significant at the 0.01 level.

\* Correlation is significant at the 0.05 level.

desk width was assessed as 64.13 cm at hand reach length for 5% value of female students' population. When these data were taken into consideration, desk width was found to be suitable for female students. Even if desk width was suitable, any person above average has to use either his body flexion while writing or will make extreme elbow flexion without any support. Bendix and et al. state that back support will evade in this position, and unsupported seating position brings out unbalanced seating without any external support owing to trying to keep balance with hip joint and body muscles. Bendix et al. indicate that the back support will disappear in this position, and the unsupported sitting position would be unbalanced to sit without an external support because of the balance provided by the muscles of the hip joint and trunk (15).

To Agha, very shallow seating aren't suitable and back muscle contraction is enhanced as a result of keeping body balance (16). Panagiotopoulou et al. stresses that very shallow seating contributes to fatigue and disorders by affecting muscle contractions (17). Very high seating are also said to be unsuitable as a result of leading a kyphotic posture among students. This is in agreement with Castellucci et al. report as very high chairs increase the incidence of back pains among students (18).

The Height of Sitting Surface of seat element in our study as shown as f in table 1, was assessed as 41 cm. 5% value for the population was assessed as maximum measurement for Popliteal Height in order to define seat setting surface. The value for 5% in males was assessed as 39.64 cm and when nearly 2-3 cm of shoe heel height is considered to be added to this value, the height of sitting surface can be said to be at the level and suitable. The value for 5% in females was assessed as 38.20 cm and even when nearly 2-3 cm of shoe heel height is considered to be added to this value, the height of seat setting surface can be said to be unsuitable for some students. And this resulting in some circulation problems in fossa poplitea because of unequal feet resting on the ground for long term sitting and as a result of this, the person will try to keep his body balance by changing his posture to compensate for this. Saarni et al. indicate that a kyphotic posture occurs among those writing on very low seating (19).

The value to be considered for the upper part height is Desk Height as shown as III in table 1. In this study 70 cm was assessed as desk height. The values measured for male students were as minimum 63 cm, maximum 109 cm ve 79.63 cm for 5% value. The values measured for female students were as minimum 65 cm, maximum

100 cm ve 73.22 cm for 5% value. When these values are taken into consideration, there occurs an incidence of sight problems for the board among students, as a result of the classrooms' not being seated like an amphitheater. And also considering these values, those students with a more distance between desk height and upper part height will be faced with a kyphotic posture for long term as a result of leaning more while writing.

Tunay et al. determined suitable and unsuitable desk measurements for university students and they indicated the desks to be suitable for the easy change of positions. Even desks in our university were produced according to the norms of Turkish Standard Institute (TSE) a difference in some anthropometric parameters was noticed (20).

The distance between Seat Back-Row Distance, as shown as g in table 1, measured as 51 cm in the study. The criteria to be considered here is Buttock-Knee Distance. This distance was calculated as 57.97 cm for 95% value in males and 59.92 cm for females. The buttock-knee distance for both male and female students was found to be unsuitable in our study and this resulting in limitations in freedom of movement. Considering females' life quality correlation table, meaningful relations between buttock-knee distance and all life quality points was noticed. In terms of freedom of movement, unsuitable desk dimension will have a negative impact on persons' life quality by causing pains for long term. Castellucci et al. state that a student sitting on an improperly designed chair may be faced with musculoskeletal disorders as a result of muscular fatigue and musculoskeletal pains, and accordingly, loss of concentration and this, leading to poor academic performance (18).

The Height from the Row to the Ground, as shown as VII in Table 1, was measured as 48 cm in the study and this can be compared with knee height. Knee height for males was assessed as 62.04 cm for 95% value. Knee height for males was found to be unsuitable. Considering life quality correlation of males, knee height was noticed to affect their physical life quality. Knee height for females was assessed as 58.01 cm for 95% value and this was defined as unsuitable for female students.

Norm values for new furniture designs were determined by calculating anthropometric measurements that must be updated in terms for the continuously changing population. Musculoskeletal disorders owing to the long term use of ergonomically unsuitable desks by determining fit and unfit measurements in desk dimensions and the effect of this on life quality are explained. There seems to be a need for more studies to be conducted in the field of how anthropometric measurements affect the life quality, as the number of detailed studies on the impact of anthropometric measurements on life quality is very few.

Students' suffering from musculoskeletal pains at university level and, as a result of this, the low quality of their life will have a great impact on their work life. For this reason, some precautions must be taken in order to prevent some health disorders and make contributions to a good academic performance and try to enable more healthy generations.

Limitations of our study; based only on the single-type row within the scope of the School of Health Sciences, low number of sample of the study. Our population is evaluated in terms of posture analysis and there is a need for comprehensive research which evaluates the long term effects of row ergonomics and evaluates other departments in the university. We believe that the data and results obtained in our study will be the basis for future anthropometry studies.

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