

ESTABLISHMENT OF ANTHROPOMETRIC REFERENCE VALUES FOR DESIGN WITH REGARD TO DENTAL ERGONOMICS

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ABSTRACT

Dental ergonomics, which is a sub-branch of ergonomics emphasize that, the fact that all equipment and tools made available to dentists and patients fits the dimensions of the user is of the primary priority for health, work productivity and motivation for the tasks. In line with this purpose, 27 anthropometrical body measurements are taken in accordance with International Biological Program and Anthropometric Standardization Reference Manual, from 200 adult individuals, 100 female and 100 male from medium and upper socio-economic level in Ankara in order to determine anthropometrical values of our country people's values.

As the height and weight are most used indicators that reflects the general morphology; in this study with the average age of 27.43 years, height calculated as 1671.22 mm and weight 64.98 kg. According to the sexes, the height and weight values are as follows; females 1604.03 mm and 56.56 kg; males 1738.40 mm and 73.40 kg.

The results indicate that our people have unique anthropometrical values different from those of other people. Both female and male individuals' height, sitting height, knee height and buttock-knee lengths are lower than North Europe and North American groups and higher than South East Asian groups. Knee height and hip-knee length of Turkish women be found to be lower than those South East Asia women. The other attract attention result is, comparing with all

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other groups for both sexes our people's hand breadth and hand length parameters are higher than the others. Those values that we determined clearly shows the necessity and importance of the design, which are unique to our society.

Key words: Anthropometrics, dental ergonomics, Turkish people

DENTAL ERGONOMİ AÇISINDAN TASARIMLAR İÇİN ANTROPOMETRİK REFERANS DEĞERLERİNİN OLUŞTURULMASI

ÖZET

Ergonomi disiplininin alt dallarından biri olan dental ergonomi, diş hekimi ve hastanın kullanımına sunulan her türlü alet ve ekipmanın kullanıcı boyutlarına uygun olmasının sağlık, iş verimi ve işe motivasyon açısından öncelikli olduğunu önemle vurgulamaktadır. Bu amaç doğrultusunda ülke insanımızın antropometrik değerlerini tespit etmek için Ankara'da orta ve üst sosyoekonomik düzeyden erişkin 100 kadın ve 100 erkek, toplam 200 bireyden, International Biological Program ve Anthropometric Standardization Reference Manual'in teknikleri doğrultusunda 27 antropometrik vücut ölçüsü alınmıştır.

Ağırlık ve boyun genel vücut morfolojisini yansıtmada kullanılan en belirleyici özellikler olduğu dikkate alındığında, çalışmamızda 27.43 yıl genel yaş ortalamasına sahip bireylerin boy ortalaması 1671.22 mm ve ağırlık ortalaması 64.98 kg olarak hesaplanmıştır. Cinsiyetler açısından boy ve ağırlık değerleri ise; kadınlarda 1604.03 mm ve 56.56 kg, erkeklerde 1738.40 mm 73.40 kg'dır.

Araştırma sonuçlarının istatistikî analizleri ve persentil değerlerinin diğer ülke değerleri ile karşılaştırılması sonucunda, ülke insanımızın diğer toplumlardan farklı ve kendine özgü antropometrik değerlere sahip olduğu gözlemlenmiştir. Hem kadınlar hem de erkekler açısından boy, büst yüksekliği, diz yüksekliği ve kalça-diz uzunluk değerleri Kuzey Avrupa ve Kuzey Amerika gruplarından oldukça düşük değerde, Güney Doğu Asya gruplarından yüksek değerde bulunmaktadır. Dikkat çekici bir diğer sonuç ise her iki cinsiyet açısından da el genişliği ve el uzunluğu parametrelerinin karşılaştığımız tüm diğer gruplardan yüksek oluşudur. Tespit ettiğimiz oldukça farklı değerler, toplumumuza özgü tasarımların gerekliliğini ve önemini açıkça ortaya koymaktadır.

Anahtar kelimeler: Anthropometri, dental ergonomi, Türk insanı

INTRODUCTION

It's known that populations have certain anatomic, anthropometrical and psychological characteristics. For ergonomic design, determining anthropometrical dimensions with taking into consideration of the biological and psychological characteristics of the people as well as their capacities and make design of tools, machinery, system, works, structures, hardware and ambient conditions thus increasing efficiency by ensuring both safe, healthy, comfortable, easy and effective use for this and motivation of the users is a necessity (Sabanci, 1999; Erkan, 1995; Sanders and McCormick, 1987).

Anthropometrics is a technique, which examines physical and biological form in metrical aspects, which such physical and biological form is shaped within the framework of genetic and environmental factors. Determining unique values of each society, establishing certain standards and making designs by taking these standards into consideration is a must for each society. Great role of anthropometrical data for health and efficiency of the users in equipment and tool designs and the fact that this data represents the relevant population is very important. We may tell that subject matter of "Dental Ergonomics" is design of any and all equipment and environment, which are made available during dental procedure, and principles of operation. In addition it is striking in this field it is very limited in Turkey (Cushman and Rosenberg, 1991; Helander, 1995; Uzel and Gür, 1999).

User protection laws that exhibits importance and requirement of the ergonomics and constitute enforcement power, fulfils important duties in the developed countries. We believe that designers and dentists as well as patients insists on ergonomics design, shall play an important role in realization of the innovations in this field.

Unique anthropometrical values of each society are created as a mutual interaction of the genetic and environmental factors. It is intended to make a contribution in anthropometrics perspectives, to determining anthropometrical values of our society and combining them with new technologies, realizing a working environment, which is in compliance with ergonomics standards with regard to dentistry.

In addition to those design which are made by taking into consideration of the physical and psychological health and safety of the dentist and patient, in compliance with anthropometrics parameters, adapting such factors as illumination of the working environment, ventilation and temperature to the people increases functional working speed, and ensures working ease with regard to patient and dentist. During dental procedure, prolonged movement group is repeated over

and over in the body of the dentist. Besides the vibratory and pulsing tools, those movements which requires application of force, imbalance and physical challenges occurring at extremities and fingertips influences the patient physically and psychologically as much as dentist. When all these factors are taken into consideration it is compulsory to make ergonomics designs by taking into consideration of anthropometrical values of each society (Uzel and Gür, 1995).

METHOD

Subjects

In this study, 100 adult female and 100 adult male were randomly selected amongst the personnel and students of Gazi University, Faculty of Dentistry, and Ankara University, Faculty of Letters as well as various people in various professional groups and a representative group of total 200 persons were formed.

Body Dimensions

In accordance with the techniques prescribed in International Biological Program (IBP) and Anthropometric Standardization Reference Manual, measurements of height, weight, arm reaching distances, sitting height, eye and shoulder height, shoulder and elbow breadth, chest depth, full arm, upper arm and forearm length, wrist and hand breadth, hand and finger length, wrist and hand circumference, hip and buttock breadth, hip-knee, upper leg and lower leg lengths, knee height as well as head breadth are taken from each individual. The values taken are statistically assessed in SPSS program and 5th, 50th, 95th percentile values are calculated (Akin, 2001; John, 1981; Martin and Saller, 1957; Phesant, 1990).



Figure 1: Sitting Height



Figure 2: Waist Height

RESULTS

Average age of our working group is 27,43. When we assess average as per sexes, they are determined to be 25,75 for women and 29,11 for man. Our samples mainly represent medium and upper socio-economic classes. Measurement values of entire sample are given in Table 1.

Table 1: Anthropometrical data of the sample (n: 200)

Measurements	Mean	SD	Min	5th	50th	95th	Max
Height (mm)	1671,22	9,48	1475,00	1541,00	1663,00	1822,90	1905,00
Weight (kg)	64,98	12,83	35,00	48,81	62,85	87,75	118,00
Standing overhead reach (mm)	2133,29	13,49	1830,00	1940,00	2121,50	2133,00	2500,00
Sitting height (mm)	881,78	44,20	750,00	812,50	880,50	956,00	997,00
Sitting eye height (mm)	775,04	44,22	660,00	711,00	775,00	846,50	897,00
Shoulder height (mm)	572,62	34,56	465,00	517,10	571,00	625,00	663,00
Shoulder breadth (mm)	397,07	26,78	305,00	325,00	364,00	410,00	427,00
Chest breadth (mm)	273,41	29,94	220,00	234,10	270,50	314,00	441,00
Chest depth (mm)	181,64	28,17	126,00	152,10	185,00	232,00	325,00
Wrist breadth (mm)	64,23	5,79	51,00	56,00	64,00	71,00	76,00
Shoulder-d fingertip length (mm)	733,82	55,40	602,00	662,00	731,00	822,90	845,00
Upper arm length (mm)	343,01	32,20	285,00	305,00	340,00	385,95	410,00
Forearm length (mm)	263,37	38,00	210,00	230,10	261,50	295,00	305,00
Wrist length (mm)	56,48	4,86	45,00	47,00	54,00	63,00	66,00
Head breadth (mm)	99,85	9,21	75,00	85,10	100,00	114,00	132,00
Head length (mm)	191,77	15,80	160,00	168,10	191,00	214,00	233,00
Head circumference (mm)	241,22	23,70	140,00	210,00	240,00	276,00	292,00
Finger length (mm)	99,73	8,40	79,00	86,00	100,00	114,00	124,00
Wrist circumference (mm)	164,28	14,70	130,00	143,00	161,50	188,00	226,00
Hip breadth (mm)	291,31	29,72	177,00	250,00	287,00	341,90	421,00
Trochanteric breadth (mm)	323,24	25,82	225,00	269,10	321,00	366,00	429,00
Buttock-popliteal length (mm)	459,97	37,17	348,00	399,00	459,00	513,90	647,00
Buttock-knee length (mm)	562,22	33,49	440,00	508,10	561,50	615,00	699,00
Knee height (mm)	510,25	39,14	401,00	451,00	506,00	584,00	625,00
Wrist height (mm)	949,87	56,69	813,00	905,00	942,00	1046,00	1110,00
Lower leg length (mm)	453,41	38,79	350,00	384,10	449,50	518,00	599,00
Heel breadth (mm)	156,16	7,53	136,00	144,00	155,00	169,00	178,00

It is accepted by all scientists that there is a difference between sexes in the society. Especially, given the designs, it is mandatory to determine 5th and 95th percentile values to address all segments of the society. Since in ergonomics, 5th percentile value of the women better represents lower 5th of the population and 95th percentile value of the men better represents upper 95th of the population. For this reason, it is important to evaluate

measurement values of the women and men by taking the sexual differences (Jurgens et al., 1990). Measurement values of females and males we obtain in our study are given in Table 2 and Table 3.

Table 2: Anthropometrical data of females

Measurements	Mean	SD	Min	5th	50th	95th	Max
Height (mm)	1604,03	5,76	1475,00	1514,00	1598,50	1710,00	1741,00
Weight (kg)	56,56	6,82	39,00	47,00	55,30	70,30	78,00
Standing overhead reach (mm)	2040,30	8,15	1810,00	1920,00	2005,00	2150,00	2230,00
Sitting height (mm)	855,32	31,43	795,00	805,10	853,50	912,70	933,00
Sitting eye height (mm)	750,64	32,42	664,00	701,10	751,00	806,00	835,00
Shoulder height (mm)	553,73	27,58	465,00	513,00	553,50	602,00	624,00
Shoulder breadth (mm)	348,11	17,18	303,00	321,30	350,00	380,20	400,00
Chest breadth (mm)	256,67	25,32	223,00	231,00	254,00	285,00	441,00
Chest depth (mm)	174,58	21,81	126,00	151,00	173,00	203,00	254,00
Wrist breadth (mm)	60,35	3,58	51,00	55,00	61,00	66,00	69,00
Shoulder fingertip length (mm)	698,81	44,50	632,00	647,10	692,50	740,10	768,00
Upper arm length (mm)	330,72	35,40	283,00	297,30	326,00	365,00	370,00
Forearm length (mm)	252,67	49,20	215,00	226,10	243,00	269,00	273,00
Wrist breadth (mm)	50,99	3,08	45,00	46,00	51,00	57,00	61,00
Hand breadth (mm)	93,15	5,87	73,00	84,00	93,00	103,00	107,00
Hand length (mm)	184,06	10,28	140,00	166,10	184,50	203,00	208,00
Hand circumference (mm)	224,61	16,87	146,00	206,10	224,00	248,00	278,00
Finger length (mm)	84,69	6,31	73,00	85,00	95,00	105,00	107,00
Wrist circumference (mm)	153,91	8,60	138,00	140,10	154,00	170,00	180,00
Hip breadth (mm)	280,11	25,76	177,00	245,10	275,50	322,30	384,00
Thoracostern breadth (mm)	317,46	20,98	265,00	286,10	314,00	356,90	369,00
Buttock-popliteal length (mm)	855,32	31,43	795,00	791,10	841,50	888,00	933,00
Buttock-knee length (mm)	543,51	23,48	483,00	503,10	543,50	584,90	595,00
Knee height (mm)	402,04	23,43	431,00	445,10	485,00	529,00	540,00
Waist height (mm)	917,45	41,88	811,00	833,20	915,90	1006,00	1030,00
Lower leg length (mm)	440,39	37,23	350,00	382,10	440,00	506,70	543,00
Head breadth (mm)	151,73	5,53	139,00	142,00	152,00	163,00	164,00

Table 3: Anthropometric data of males

Measurements	Mean	SD	Min	5th	50th	95th	Max
Height (mm)	1738.40	7.50	1555.00	1609.10	1745.00	1807.80	1903.00
Weight (kg)	73.40	11.44	49.00	56.61	73.00	92.86	118.00
Standing overhead reach (mm)	2225.90	11.26	1950.00	2040.50	2250.00	2419.50	2550.00
Sitting height (mm)	908.24	39.03	823.00	835.50	916.00	963.00	997.00
Sitting eye height (mm)	799.43	40.96	603.00	735.00	801.50	852.90	897.00
Stoekler height (mm)	291.20	29.87	224.00	240.00	291.50	347.00	363.00
Stoekler breadth (mm)	386.00	20.51	340.00	351.00	387.50	420.90	427.00
Chest breadth (mm)	200.33	24.38	220.00	254.20	289.50	320.70	395.00
Chest depth (mm)	202.77	26.79	155.00	168.20	198.50	232.20	335.00
Wrist breadth (mm)	68.07	5.95	58.00	61.00	68.50	74.00	76.00
Shoulder-garment length (mm)	748.83	39.10	675.00	693.10	774.00	838.90	845.00
Upper arm length (mm)	358.29	22.80	283.00	309.30	355.00	394.00	410.00
Forearm length (mm)	274.07	15.70	229.00	243.00	275.00	300.50	305.00
Wrist breadth (mm)	57.96	3.67	45.00	51.20	56.50	64.00	66.00
Hand breadth (mm)	106.54	6.70	90.00	97.00	106.00	116.90	132.00
Hand length (mm)	199.47	16.68	164.00	171.60	203.00	219.00	233.00
Hand circumference (mm)	257.83	16.94	173.00	233.10	259.00	283.00	292.00
Pager length (mm)	104.77	7.32	88.00	92.10	105.00	116.00	124.00
Wrist circumference (mm)	174.64	11.97	148.00	155.00	173.00	195.80	226.00
Hip breadth (mm)	302.51	29.27	237.00	256.10	299.50	350.00	421.00
Thyoacanthic breadth (mm)	329.02	25.15	225.00	299.00	328.00	368.00	429.00
Buttock-popliteal length (mm)	477.21	33.72	400.00	428.40	473.00	530.00	647.00
Buttock-knee length (mm)	580.59	31.61	440.00	513.10	581.50	628.90	659.00
Knee height (mm)	558.14	30.68	464.00	493.10	538.50	593.90	625.00
Waist height (mm)	982.29	50.81	860.00	895.10	977.00	1089.20	1110.00
Lower leg length (mm)	466.43	28.12	400.00	416.00	460.50	523.70	589.00
Head breadth (mm)	190.00	6.78	147.00	150.00	161.00	175.90	178.00

Table 4 and 5 have been established by comparing percentile values from three of 20 populations of the various regions of the world which were taken with support of ILO's International Safety and Health Information Center with 5th, 50th and 95th of some of our measurements (Jurgens et al., 1990).

Table 4: Comparison of Turkish females' percentile values with different groups

Measurements	Turkey			North America			North Europe			Southeast Asia		
	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
Height	151.4	159.3	171.1	154.5	163.0	173.0	158.0	166.0	176.0	146.6	157.0	168.0
Sitting height	88.1	93.3	101.7	83.0	88.0	95.0	84.0	90.0	98.0	77.0	82.0	87.0
Eye height	79.1	77.0	80.6	70.0	76.0	83.0	71.0	76.0	82.0	68.0	70.0	74.0
Shoulder breadth	321.2	350	383.8	330	360	385	320	355	385	218	240	270
Knee height	460	483	520	460	500	530	460	500	530	460	475	515
Hip-knee	309	343.3	384.9	320	370	430	340	390	430	500	550	590
Wrist height	833.2	915.1	1006.6	840	1000	1100	860	1000	1100	890	970	1050
Hand breadth	84	95	105	74	75	85	79	80	85	73	75	80
Hand length	196.1	194.3	205	160	170	180	160	175	180	165	170	180
Head breadth	140	152	162	135	145	155	140	150	158	125	135	140

Table 5: Comparison of Turkish male' percentile values with different groups

Measurements	Turkey			North America			North Europe			Southeast Asia		
	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
Height	169.2	174.7	187.8	167.0	179.0	190	171.0	183.0	193.0	150.0	163.0	172.0
Sitting height	83.3	84.6	86.1	80.0	85.0	89.0	80.0	85.0	89.0	79.0	84.0	88.0
Eye height	75.5	80.2	82.5	70.0	81.0	86.0	77.0	83.0	87.0	68.0	73.0	78.0
Shoulder breadth	351	391.2	425.9	360	395	430	360	400	430	320	370	420
Knee height	493.3	530.7	563.9	500	550	600	505	550	600	455	495	525
Hip-knee	353.1	341.5	326.9	370	400	440	340	370	410	490	530	570
Wrist height	895.3	977	1069.3	890	1000	1100	900	1000	1100	845	870	915
Hand breadth	97	106	118.9	83	87	93	82	85	95	75	80	85
Hand length	211.8	203	218	175	190	205	185	195	205	160	170	180
Head breadth	130	141	151.8	145	155	165	145	150	158	115	125	130

When 50th percentile values of Turkey, North America, North Europe and South East Asia country's women are examined in Table 4, while height, sitting height, shoulder breadth, knee height, hip-knee and lower leg length of North America and North Europe are found to be higher than those of our country's women, hand breadth, hand length and head breadth have been determined to be higher in Turkish women. Knee height and hip-knee length of Turkish women be found to be lower than those South East Asia women, other anthropometrical values have been found to be higher than their values.

When Table 5 is examined, North American and North European men have higher values than those anthropometrical values of Turkish man save hand with, hand length and head breadth, all anthropometrical values of South East Asia men are lower than those of Turkish men.

DISCUSSION AND CONCLUSION

Equipment used by the dentist and patient during dental procedure may be far below or above the anthropometrical values of the individuals. In this case, it is necessary to design the equipment in such a way that it can be adjustable between 5th and 95th percentile value of the society (Tilley, 1993; Cushman and Rosenberg, 1991).

The fact that dentists are on foot for prolonged times while dealing with the patients' leads to back, neck and foot pains. It must be ensured that dentists sit on a mobile chair. In design of the dentist chair, 368 mm which is 95th percentile value of the male throchanteric breadth must be used for seat width and 391,1 mm which is 5th percentile value of the female upper length must be used for seat length. Seat width of the patient chair must be 368 mm which is 95th percentile of the male throchanteric breadth and length of the same section must be 1089,3 mm which is 95th value of the male lower leg length. For backrest of the seating groups, 420,9 mm is recommended which is 95th percentile value of the male shoulder breadth. For back height including head rest, 963 mm which is 95th percentile value of the sitting height is recommended for absolute seating height 647 mm which is 95th percentile value of the male shoulder height is referred to. In addition, for wide-angle adjustability and breadth of the headrests, 175,9 mm is recommended which is 95th percentile value of male head with (Tilley, 1993).

In our study, for minimum and maximum height values of design of the adjustable dentist chair, unit and other equipment, 445 mm which is 5th percentile value of the knee height of women and 593,9 mm which is 95th percentile value of men is given as references. In addition, for those cases of non-adjustability 50th percentile value can also be used in accordance with field of utilization of the equipment (Tilley, 1993).

As for maximum reaching distance, 1920 mm which is 5th percentile value of the women and 647,1 mm which is 5th percentile value of full arm length of the women shall be taken into consideration (Tilley, 1993).

Today's people are divided into "Northern people" and "Southern people". It is doubtless that differences determined in socio-economic levels and level of development is reflected in the body dimensions. When we compare the values that we obtained with different societies, it seems that Turkey exhibits average values between Northern and Southern people. When we look at overall body structure, it is determined lower section lengths of Turkish people are lower than other populations'. It is found that their sitting height is lower than North America and North Europe and higher than South East Asia. However, it must kept in mind

that height of South Asian people is 11 cm shorter than Turkish people. It exhibits similar structures in other measurements (Jürgens, 1990).

It is a reality that establishing and implementing ergonomic standards are not only hard for the studies but also brings about some financial difficulties. However, the fact that we have anthropometrical values very different from those of other societies and necessity to take human factors in the design clearly indicates that we have to work out further on these studies. We believe that approaching to dental ergonomics studies which are very restricted in Turkey, in practical ways and offering more permanent solutions to the problems shall be more convenient.

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