

AN ESTIMATION OF ANTHROPOMETRIC CHARACTERISTICS OF
ADULT FEMALE POPULATION OF TURKEY

by

Cansu Ergün

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Tansel, tez boyunca verdiğin tüm destek için, hep içten bir kardeş olduğun için teşekkürler. Babam, sevgin ve güvenin beni hep ayakta tuttu. Ve güzel annem, arkadaşım, bu tez için ben kadar çalıştıysam sen de o kadar çalıştın, bu tez senin sayende var. Ne zaman devam etme gücüm olmasa “geçecek” dersin ve geçer. Yine öyle oldu. İyi ki varsınız, iyi ki ailemsiniz. Şu zamana kadar benim için vazgeçtiklerinizin, emeklerinizin ve sevginizin karşılığı yok. Her şey için teşekkür ederim.

ABSTRACT

AN ESTIMATION OF ANTHROPOMETRIC CHARACTERISTICS OF ADULT FEMALE POPULATION OF TURKEY

Ergonomics is concerned with the fit between people and work, tool, equipment, vehicle and the environment. Anthropometry, the science of human body measurements, is a field that contributes to ergonomic design. Optimal designs for people (e.g.; designs of workspaces, tools, machines, vehicles and personal protective equipment) involves the use of anthropometric data. Anthropometric measures may vary among world populations from different regions. Hence, every country may require its own anthropometric database. Even though there exist a number of studies on the anthropometric measurements of population of Turkey, the available data are not enough and statistically sound in establishing a useful and valid anthropometric database. Therefore, the main objectives of this study were as follows: (i) to generate an up-to-date anthropometric database of adult female population of Turkey; (ii) to investigate the effects of age and occupation on body dimensions; and (iii) to compare the results with prior female anthropometric data of Turkey and with other nationalities. In order to reach the stated objectives, 65 static and dynamic body dimensions were taken from 250 adult females aged from 18 to 79 yrs. Sampling is done in a stratified manner including subjects from seven regions of Turkey. Subjects were divided into two occupational (manual and non-manual) and five age groups (18 to 79 separated by 10 years). Results showed that stature and other vertical body dimensions as well as length dimensions were significantly decreasing with age. Some breadth, depth and circumference dimensions were significantly increasing with age. Comparing to a study in 2006, there is a 1.5 cm increase in stature and a no significant decrease in body mass. When compared to the results of other nationalities, anthropometric data of the female population of Turkey, in general, is similar to the Algerian and Cuban, greater than Malaysians, Chinese and Thai adults and lower than Northern Europeans.

ÖZET

TÜRKİYE YETİŞKİN KADIN NÜFUSUNUN ANTROPOMETRİK ÖLÇÜMLERİNİN TAHMİNLEMESİ

Ergonomi, kullanıcıların donanım, iş ve çevre ile aralarındaki uyum ile ilgilenir. Antropometri, insan vücut ölçümleri ile ilgili bilim dalı, ergonomik tasarımlara önemli katkıda bulunur. İnsanlar için optimal tasarımlar antropometrik veri kullanımını gerektirir (ör.; iş istasyonu, alet, ekipman, makine ve araç tasarımları). Antropometrik ölçüler ülkelerarası farklılıklar gösterebilir. Bu nedenle, her ülkenin kendine ait antropometrik veritabanının olması ergonomik tasarımlar için gereklidir. Türkiye nüfusunun antropometrisi üzerine yapılmış birçok çalışma olsa da, mevcut verilerden, kapsam ve istatistiksel özellikler açısından, kullanışlı ve geçerli bir antropometrik veritabanı oluşturmak mümkün değildir. Bu nedenle, bu çalışmanın temel amaçları şunlardır: i) yetişkin Türkiye kadın nüfusunun vücut ölçüleri için güncel bir veritabanını oluşturmak; (ii) yaş ve meslek faktörlerinin vücut ölçüleri üzerindeki etkisini araştırmak; ve (iii) sonuçları daha önce yapılan çalışma sonuçları ile karşılaştırmak. Bu amaçla, 18-79 yaş arası 250 kişilik örneklemden statik ve dinamik toplam 65 adet vücut ölçüsü alınmıştır. Örneklem, Türkiye'nin yedi bölgesinden seçilerek tabakalandırılmış metodla yapılmıştır. Örneklem, 2 meslek grubu (ağır ve hafif işler) ve 5 yaş grubuna (18 79 arası ve her bir grup 10 yılı içerecek şekilde) bölünmüştür. Bu çalışmanın sonucu olarak, Türkiye yetişkin kadın nüfusundan alınan 65 vücut ölçüsü, istatistiksel olarak belirlenmiştir. Sonuçlar, boy ve diğer dikey vücut ölçülerinin yaş ile birlikte belirgin bir biçimde kısaldığını göstermiştir. Bazı genişlik, derinlik ve çevre ölçümleri ise yaş ile birlikte belirgin bir biçimde artmaktadır. 2006'da yapılmış bir çalışma ile karşılaştırıldığında, kadınların boylarında ortalama 1.5 cm'lik artış olduğu ve ortalama vücut ağırlıklarında bir değişim olmadığı gözlenmiştir. Diğer ülkelerin sonuçları ile karşılaştırıldığında ise, Türkiye'deki kadın nüfusunun antropometrik ölçümleri, Cezayirli ve Kübalılar'inkine benzerken; Malezyalılar, Çinliler ve Taylandlılar'inkinden büyük; Kuzey Avrupalılar'inkinden ise küçük olduğu görülmüştür.

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LIST OF ACRONYMS/ABBREVIATIONS

ANOVA	Analysis of variance
BMIP	Body mass index prime
cm	Centimeter
diff	Difference
Dist.	Distribution
ht	Height
kg	Kilogram
N/A	Not available
SE	Standard error
std. dev.	Standard deviation
yrs	Years
CV	Coefficient of Variation
Meas.	Measurement
anthro meas	Anthropometric Measurement
BM	Body mass (kg)
Stature (e)	Stature (erect)
Stature (n)	Stature (normal)
Eye ht (e)	Eye height (erect)
Eye ht (n)	Eye height (normal)
Acr. (shld) ht (e)	Acromial (shoulder) height (erect)
Acr. (shld) ht (n)	Acromial (shoulder) height (normal)
Elbow ht (n)	Elbow height (normal)
Fngtip ht (n)	Fingertip height (normal)
Th-tip ht (n)	Thumb-tip height (normal)
Fist(gr.ax, knck)ht (n)	Fist (grip axis, knuckle) height (normal)
Waist ht (n)	Waist height (normal)
Vertical grip rch	Vertical grip reach
Vertical th-tip rch	Vertical thumb-tip reach
Vertical fngtip rch	Vertical fingertip reach
Forward grip rch	Forward grip reach

Forward th-tip rch	Forward thumb-tip reach
Forward fngtip rch	Forward fingertip reach
Span	Span
Elbow span	Elbow span
Chest (bust) depth	Chest (bust) depth
Chest (bust) brt	Chest (bust) breadth
Stand. e-to-e brt	Standing elbow-to-elbow breadth
Shld-elbow lgt	Shoulder-elbow length
Shld-fngtip lgt	Shoulder-fingertip length
Shld-fist (grip axis) lgt	Shoulder-fist (grip axis) length
Foot lgt	Foot length
Foot brt	Foot breadth
Sit. ht(e)	Sitting height(erect)
Sit. ht (n)	Sitting height (normal)
Sit. eye ht (e)	Sitting eye height (erect)
Sit. eye ht (n)	Sitting eye height (normal)
Sit. acr. (shld) ht (e)	Sitting acromial (shoulder) height (erect)
Sit. acr. (shld) ht (n)	Sitting acromial (shoulder) height (normal)
Sit. elbow rest ht (n)	Sitting elbow rest height (normal)
Knee ht	Knee height
Popliteal ht	Popliteal height
Buttock-knee lgt	Buttock-knee length
Buttock-popliteal lgt	Buttock-popliteal length
Thigh clearance	Thigh clearance
Buttock-Leg Lgt	Buttock-Leg Length
Sit.vertical grip rch	Sitting vertical grip reach
Sit.vertical th-tip rch	Sitting vertical thumb-tip reach
Sit.vertical fngtip rch	Sitting vertical fingertip reach
Sit.forward grip rch	Sitting forward grip reach
Sit.forward th-tip rch	Sitting forward thumb-tip reach
Sit.forward fngtip rch	Sitting forward fingertip reach
Head circumf	Head circumference
Head lgt	Head length

Head brt	Head breadth
Ment-sellion (face) lgt	Menton-sellion (face) length
Bizygomatic (face) brt	Bizygomatic (face) breadth
Neck circumf	Neck circumference
Chest circumf	Chest circumference
Waist circumf	Waist circumference
Hip brt (sit.)	Hip breadth (sitting)
Sit. e-to-e brt (n)	Sitting elbow-to elbow breadth (normal)
Shld biacr. brt	Shoulder biacromial breadth
Shld bideltoid brt	Shoulder bideltoid breadth
Hand lgt	Hand length
Hand brt	Hand breadth
Palm lgt perp	Palm length perpendicular
Index finger lgt	Index finger length
Hand circumf	Hand circumference
Wrist circumf	Wrist circumference

1. INTRODUCTION

Ergonomics is the design and engineering of human-machine systems for the purpose of enhancing human performance (Dempsey *et al.*, 2000). The definition involves the application of engineering design to the study and production of safe and efficient human-machine systems (International Encyclopedia of Ergonomics and Human Factors, 2006). Anthropometrics deals with the body measurements in order to determine the optimum size of products for efficient and comfortable use. Therefore, ergonomic design involves relevant anthropometric data to ensure the fit between human and products or workplaces.

Ergonomics is concerned with humanizing work and technology systems such as making work and technology systems safe, efficient and satisfying. Specifically, (i) protecting workers from serious physical or mental harm, (ii) maximizing health, safety and well-being, (iii) optimizing performance and efficiency, (iv) maximizing productivity and quality, (v) maximizing product usability and user acceptance, (vi) improving quality of life (Ekşioğlu, 2013).

The term ergonomics came into use about 1950 when the priorities of developing industry were taking over from the priorities of the military. In immediate postwar industry the overriding objective, shared by ergonomics, was greater productivity. Gradually, mechanical power replaced human muscle power. More power, however, leads to more accidents on the simple principle that an accident is the consequence of power in the wrong place at the wrong time. When things are happening faster, the potential for accidents is further increased. Thus, the concern of industry and the aim of ergonomics gradually shifted from productivity to safety (ILO Encyclopedia of occupational health and safety, 1998).

Developing a science-based ergonomics application involves and inevitably overlaps with many related disciplines. Being one example of those disciplines, anthropometry is a field of human sciences, which deals with human body measurements to achieve comfort, measurements of the size, fit and usability. In an ideal design process,

anthropometric data is compared with relevant product and workplace measurements, for instance, popliteal height with chair height (Pentikis et al., 2002). All types of products including clothes, and systems of products such as vehicles and assembly lines, and office workplaces need to be adjusted to the anthropometric measurements of the human to maximize usability and minimize the negative effects on the human. The fit between different products or workplaces and human beings is not always optimal (Wichansky, 2000; Pentikis *et al.*, 2002). In order to minimize anthropometric mismatch between product or workplace and human beings, relevant corrections and updates for anthropometric measurements should be used in the design phase of the product. In the majority of real life ergonomic design applications involving the interaction of humans with tools, instruments and systems, the information about the population of users is needed. Very often, the need is for anthropometric data. A well-designed or selected anthropometric database could provide important information for optimizing the human-machine-equipment or system interface (Herron, 1973). Considering this, most of the countries have generated their own anthropometric databases of the population.

The main aim of this study is to estimate the anthropometric measures of the adult female population of Turkey. Moreover, to investigate the effects of occupation, age and Body Mass Index (BMI) on the anthropometric characteristics of the mentioned population.

The organization of the thesis content is as the following: In Chapter 2, related literature is reviewed on the anthropometric characteristics of different female populations. In Chapter 3, rationale behind the study is stated. In Chapter 4, the methodology of the study is explained. Chapter 5 presents the general and statistical results of the study. In Chapter 6, a discussion on the results is made. In addition, this chapter involves comparisons with other studies. The last chapter covers the conclusions of the study.

2. LITERATURE REVIEW

2.1. Overview

Definition of anthropometry, anthropometry types, ISO standards, ergonomic criteria, factors affecting anthropometry, information about secular trend, techniques used in anthropometry, anatomical concepts and body dimensions used in the study are provided in this section. Reviews of anthropometric studies on several populations are also included in addition to information provided.

2.2. Anthropometry Defined

Anthropometry is the branch of the human sciences, which deals with body measurements: particularly with measurements of body size, shape, strength and working capacity. Anthropometry is a very important branch of ergonomics. It is concerned with matching the physical form and dimensions of the product or workspace to those of its user; and likewise with matching the physical demands of the working task to the capacities of the workforce. It stands alongside (for example) cognitive ergonomics (which deals with information processing), environmental ergonomics, and a variety of other identifiable sub disciplines, which progress (in parallel, as it was) towards the same overall end (Pheasant, 2000).

Anthropometry makes a significant contribution to ergonomic standardization. Nowadays, for instance, it is inconceivable that a car should be sold on the world market without appropriate account having been taken of the dimensions of the driver's body. Differences in body shape, size and physical capacities are among the most obvious manifestations of human variability. It is clearly apparent that people differ in height, weight and arm length in which body form and function can be measured (Karwowski, 2006).

2.2.1. Types of Anthropometry

Types of dimensions in anthropometry can be divided into two groups as static (structural) anthropometry and functional (dynamic) anthropometry (Fraser, 1989).

2.2.1.1. Static (structural) anthropometry. It is usually used in classical anthropometry and measured from clearly defined anatomical points, and indicates the precise length, width, diameter, and circumference of the body part involved. Some common static anthropometric dimensions are stature, sitting height, eye height sitting, eye height standing, knuckle height, and shoulder height. This type of anthropometry is important in categorizing individuals or populations, but is used limitedly in engineering design (Fraser, 1989).

2.2.1.2. Dynamic (functional) anthropometry. It deals with the body proportions and dimensions taken during the completion of various physical activities. These movements may be required for the performance of particular types of tasks. Some of the frequently used functional measurements include kneeling height, forward reach, overhead reach, and bent torso height. (Kohn, 1998)

Static and dynamic anthropometric dimensions help designers determine tool, equipment and workplace design requirements based on human body measurements.

2.2.2. Factors Affecting Anthropometry

The shapes, sizes and strengths of people are very often ‘determined by age and gender. When considering a target population for anthropometric purposes, we should also take into account, social class, ethnicity and occupation. (Pheasant, 2000)

2.2.2.1. Gender Differences. In order to design safe and healthy workspaces, industrial and ergonomic engineering techniques are often used to design with a one-gender-fits-all approach. However, generally men exceed women in almost all linear body dimensions except hip breadth. (Pheasant, 2000) The greater hip size in women but smaller sizes in most

dimensions including lengths and heights are an important for proper seats and workstations. (Fullenkamp et al., 2008)

2.2.2.2. The Secular Trend. Secular trend is to describe changes in measurable characteristics of a human population occurring over a time period. (Pheasant, 2000). It is a strong determinant of public health and shows how environmental conditions affect human size over a long period of time (Tanner, 1992). In short, the secular trend in human physical growth highlights the complex interaction between genes, physiology and environment when determining the size and shape of individuals from one generation to the next (Cole, 2003). The factors determining secular variation could not only be caused by genetic factors, but also by the socio-economic environment such as the improved nutritional quality of diet and the reduction of infectious disease by improved hygiene (Komlos, 1999; Pheasant, 2000). Many anthropometry historians and nutritionists investigated about secular trends in the characteristics of stature and weight of several populations for children and adults.

The earliest data indicate that the secular trend towards taller stature began in the early part of the 19th century and continued through most of the 20th century, although there is variation among countries as to when the positive trend started. The positive secular trend was interrupted in some countries by the conditions of World Wars I and II, but as conditions improved after the respective wars, growth in height also improved to its secular trajectory before the wars. (Malina, 2004)

Tanner (1981) emphasizes that considerable data for young adult males are available due to mandatory military conscription in many European countries during the 20th century. Studies made on changes in mean heights of conscripts in several western European countries between 1880 and 1980. On average, young adult height has increased in all countries, but the magnitude of the increase varies considerably, 3.7 cm in Portugal to 15.1 cm in the Netherlands. Young adult males in northern countries tend to be tallest, and heights decrease from north to south. Perhaps the most complete current conscript data are available for Poland, where four nationally representative samples of 19-year-old males are available between 1965 and 2001. On the average, height has increased by 6.9 cm over the 36-year interval, but the

estimated rate of secular change has declined over time. The data for Polish conscripts shows clear social stratification i.e., conscripts from families of better educational circumstances are taller than those from families with lesser education. However, the secular trend has occurred at about the same estimated rate in each group, about 1.5 to 1.6 cm/decade across the 36-year interval.

The secular height trend in women was poorly documented in the 19th century, as they were not conscripted. In the 20th century, the women's trend has been less than in men, so that the sex difference in adult height has increased with time. (Cole, 2003)

Ozer (2007) studied the secular trend in body height and weight of Turkish adults since anthropometric data on Turkish adults were relatively limited, and there was little information available regarding the occurrence of secular change. According to Ozer (2007), comparative data from Turkey demonstrate a general increase in female height between 1937 and 2006. Overall, female height increased from 152.3 cm to 158.9 cm, a rate of increase of 0.96 cm/decade while the observed rate of secular increase in height was greater in males (1.19 cm/decade). The changes in the mean weight of the Turkish population during the 69-year period from 1937 to 2006 were also studied. In summary, the mean weight of both sexes increased during this period. Overall, mean weight increased from 62.0 kg to 77.8 kg in males and from 52.9 kg to 67.0 kg in females. The rate of the secular increase was 2.29 kg/decade and 2.05 kg/decade for males and females, respectively. Results of secular trend in mean height (cm) and mean weight (kg) of Turkish males and females between 1937 and 2006 are shown in Table 2.1 and in Table 2.2.

Survey Year	Males			Females		
	n	Mean	SD	n	Mean	SD
1937	39,465	165.3		20363	152.3	
1960-61	915	169.3	5.7	661	155.4	5.4
1975	568	167.9		556	154.4	
1989	5,109	170.2	6.1			
1997	1,159	170.6	6.2	271	157.0	6.4
1999	250	172.0	7.5			
2006	703	174.1	6.9	512	158.9	6.4

Table 2.1. Mean height (cm) of Turkish males and females between 1937 and 2006.

Survey Year	Males			Females		
	n	Mean	SD	n	Mean	SD
1937	39,465	62.0		20,263	52.9	
1960	661	64.6	4.6			
1989	5,109	63.3	7.4			
1995				676	57.4	8.8
1997	1,159	65.5	10.0	271	63.8	11.7
1999	250	73.2	10.9			
2006	703	77.8	10.8	512	67.0	11.9

Table 2.2. Mean weight (cm) of Turkish males and females between 1937 and 2006.

2.2.2.3. Age Differences. At every point of human lifetime, body structure and morphology change. People experience growth and development almost in a similar pattern, however the pace differ from individual to individual. In early phases of life, and in adolescence growth and development occurs in a more accelerated way. Nevertheless, changes in adult body size occur more slowly (Plato, 1987). The slow change of body measurements among adult individuals mostly come from genetic and environmental factors (Launer, and Harris, 1996). Many studies have shown the significance of age related differences in the anthropometric characteristics of adults. One of the studies conducted on age effects in anthropometry by Bisai et. al. (2008) indicated the existence of significant age variations in both sexes of among Kora Mudi Tribals of India.

2.2.2.4. Ethnic differences. An ethnic group could be described as a population who locate in a certain geographical region and who have specific physical characteristics in common. These characteristics may be coming from genetic components, nutrition, and environmental factors such as temperature (Roberts, 1973; Roberts, 1975). The presences of ethnic minorities in a working population result in incompatibly of equipment design, which may pose a risk in if industrial safety guidelines do not consider anthropometric characteristics (Thompson and Booth, 1982).

2.2.2.5. Other factors. Other factors such as growth and development, occupation, geographical region, frequency of sportive activities and smoking/drinking habits are also affective in variation in anthropometric dimensions. (Pheasant, 2000; Bhattacharya and

McGlothlin, 1996). In literature, those factors were investigated in many studies in order to determine the significance on body characteristics alteration among individuals.

2.2.3. ISO Standards for Anthropometry

ISO (International Organization for Standardization) is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards. It is a non-governmental organization which is centered in Geneva, Switzerland; and made up of members from different countries. ISO develops standards to catalyze sustainable and equitable economic growth, international exchange of goods and services, protect health, safety and environment, and promote innovation.

Since body sizes and variation of member body population change with time, and in order to update and revise anthropometric data in a systematic way; anthropometric data for technological design are required to be presented in standards. Users of standards require the most appropriate body measurement values for their intended applications. International standards related to anthropometry could be listed as in Table 2.2.

Table 2.3. ISO standards for anthropometry.

ISO 7250-1:2008	Basic human body measurements for technological design Part 1: Body measurement definitions and landmarks
ISO/TR 7250-2:2010	Basic human body measurements for technological design Part 2: Statistical summaries of body measurements from national populations
ISO 7250-3:2015	Basic human body measurements for technological design Part 3: Worldwide and regional design ranges for use in product standards
ISO 11226:2000	Ergonomics -Evaluation of static working postures
ISO 14738:2002	Safety of machinery Anthropometric requirements for the design of workstations at machinery
ISO 15534-1:2000	Ergonomic design for the safety of machinery Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery
ISO 15534-2:2000	Ergonomic design for the safety of machinery Part 2: Principles for determining the dimensions required for access openings
ISO 15534-3:2000	Ergonomic design for the safety of machinery -Part 3: Anthropometric data

Table 2.3. ISO standards for anthropometry (cont.).

ISO 15535:2012	General requirements for establishing anthropometric databases
ISO 15536-1:2005	Ergonomics -Computer manikins and body templates -Part 1: General requirements
ISO 15536-2:2007	Ergonomics -Computer manikins and body templates Part 2: Verification of functions and validation of dimensions for computer manikin systems
ISO 15537:2004	Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs
ISO 20685:2010	3-D scanning methodologies for internationally compatible anthropometric databases
ISO 20685-2:2015	Ergonomics -3-D scanning methodologies for internationally compatible anthropometric databases - Part 2: Evaluation protocol of surface shape and repeatability of relative landmark positions

The standard ISO 7250-1:2008 was a reference guide to be applied in order to determine how to take anthropometric measurements; also it gives information to the designer and ergonomist on the anthropometrical and anatomical bases and principles of measurement which are applied in the solution of design tasks. Detailed descriptions of body mass and 55 body dimensions are introduced in this standard, based on detailed postures. There is a clear and short description (a number and a name), a notation of the measurements, a sketch, and the recommended measuring instrument and measuring method for each of the body measurement.

Another guide for anthropometric measurements was used for additional dimensions in the study, since required dimensions to be used in industry are not limited to those 56 measurements in ISO 7250-1:2008 standard applied. Dimensions which are not available in ISO standards were selected from NASA standards, developed and published by the U.S. Department of Defense Ergonomics Working Group. Moreover, in order to obtain information about the application of measurements, American National Standards Institute (ANSI) was used (American National Standards Institute, 2014).

2.3. Anthropometric Measurements

In order to design products and processes in a more accurate way, information required and type of anthropometric data is needed. Since the type of data and information required varies from one application to another, techniques of measuring anthropometric dimensions become an important part of the application. In some areas, static measurements of sitting and standing postures should be considered, whereas in others three dimensional measurements of the body part is the point of interest in order to satisfy the best fit between human and products/processes to be designed (Herron, 2006).

2.3.1. Measurement Techniques

Anthropometric measurements are taken choosing one of the two techniques as traditional techniques, and three-dimensional body scanning methods.

2.3.1.1. Traditional Techniques. Classical anthropometry is concerned with body measurements of the human body in standard postures (Kasdan and Mering, 1970). Since the human body decreases in height during the day, and is at a more relaxed state in the morning, it would be better to obtain the measurements, where possible in the morning (Montagu, 1960).

For most of the measurements, subject's body is in a straight posture, where body parts are 0, 90, 180 degrees to each other. The head is positioned at "Frankfurt plane", and pupils are on same horizontal level. If the subject is at a sitting posture, in order to ensure that the thighs are horizontal, the surfaces of foot support and seat are arranged accordingly. The subject is better to be unclothed or nearly unclothed as possible, when the measurements are taken.

2.3.1.2. Three-Dimensional Body Scanning Techniques. This technique is a more appropriate method when it is required to measure as much as possible of the body parts in one time. The output of whole body scanners is a cloud of points, usually transformed in a triangulated mesh

through the use of specific algorithms in order to support the 3D visualization of the surface and the extraction of meaningful anthropometric landmarks and measurements. (Lovato, 2010)

Recently, 3D scanning technology has come to enable anthropometry in an entirely new trend. Today, a number of 3D scanners are available on the market, which could be utilized for anthropometric measurements; these devices are usually developed using laser or Moiré-fringing-based (Lovato, 2010) technologies. In the former, several cameras acquire images by projecting a laser stripe onto the body surface: in this method, 3D points which represent the body shape could be recovered by triangulation. Examples of this kind are the scanners developed by Cyberware , Hamamatsu, Vitronic or Human Solutions (In the latter, pattern deformations on the body surface are observed with a set of cameras in order to estimate 3D points after creating light patterns on body surface. Instances of this kind are the scanners produced by Textile and Clothing Technology Corporation, i.e Telmat and inSpeck (Peavy Simmons, 2001).

Apart from the ISO standards for traditional anthropometric measurement techniques, there are two more international standards providing information on 3D body scanning techniques: ISO 20685:2010 and ISO 20685-2:2015. Those standards were mentioned in Table 2.2. ISO 20685:2010 includes protocols for using of 3-D surface-scanning systems when obtaining human body shape data and measurements that can be extracted from 3-D scans defined in ISO 7250-1. However, it does not apply to instruments which measure the location and/or motion of individual landmarks. ISO 20685-2:2015 explains body scanners which measure the human body in a single view. This part of ISO 20685 applies to the landmark positions which are determined by an anthropometrist. It is not useful for landmark positions automatically calculated by software from the point cloud. When a hand-held scanner is evaluated, it is true that the human operator can contribute to the overall error. In cases where systems are evaluated in which the subject is rotated, movement artefacts can be introduced; these can also contribute to the overall error.

Development of three-dimensional body scanning technology provides the extraction of body measurements in seconds and also allows consistent measurements. However, there are several problems which arise when adopting this technology (Peavy Simmons, 2001):

- One problem is the comparing the techniques of measurements between the scanners. When a scanner captures a specific body measurement among a number of scanners currently available, there is a significant variance. It is not probable to utilize this technology in the apparel industry, until the data capture process of these measurements can be standardized or, at least, communicated among the scanning systems.
- Another problem is the scanner companies. They are unwilling to share information about their scanning process. Some companies will provide how and what landmarks are used, how the data capture occurs, and general information about their extraction of measurements. What really needed is the real proprietary information is in the mathematic algorithms used. Nearly all scanning companies keep this secret, which is understandable since this might hurt their competitive advantage in the market.
- Thirdly, the need of some scanners to require use of landmarks. Identifying landmarks manually is time consuming and, usually, an erroneous process. Use of landmarks may also violate individual privacy. In order to find the landmark and to mark it, it is required to be in contact with the subject's skin. Scanners that find landmarks automatically are mostly make an approximate guess of the exact location. However, absolute identification is not possible without being able to touch the subject's skin.

2.3.2. Anatomical Concepts

Since anthropometric measurements are concerned with different parts of the body, and certain locations on a given body part, when measuring an anthropometric dimension, terms related to human anatomy becomes significant. Most of the measurements are made in one of the following two standard postures (Pheasant, 2000): In the standard standing posture, the subject stands erect, looks straight ahead with shoulders relaxed and his arms hanging loosely

by his sides. In the standard sitting posture, the subject sits erect on a horizontal, flat surface, looking straight ahead. His shoulders are relaxed, with the upper arms hanging freely by the sides and the forearms horizontal (i.e. the elbows are flexed to a right angle). Taking the standard standing posture as a reference, the terms which signify body's principal axes and the resultant planes are derived. Terms used to define the location, or the relative positions of points on the body structure are constructed. Commonly used terms are shown in a diagram in Figure 2.1. The figure introduces the reference planes used in anthropometry; the sagittal (XZ) plane divides the body into right and left halves; the coronal (YZ) plane proposes anterior and posterior sections of the body; the transverse (XY) plane cuts the body into superior and inferior parts (Kroemer, Kroemer, & Kroemer-Elbert, 1997)

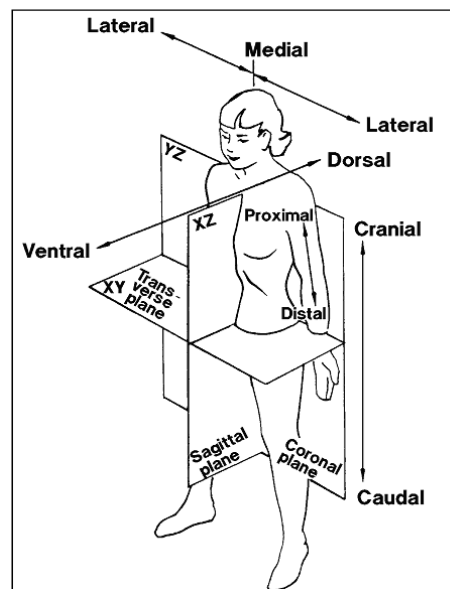


Figure 2.1. Terminology used to define position and location on the body.

The terms of orientations for particular structures or features in or on the body are could be explained as in the following: Medial stands for near the midline. Lateral means farther away from the midline. Posterior suggests at the back of the body. Anterior is used for at the front of the body. Superior stands for toward the head. Inferior suggests away from the head. The Median plane divides the body into a right and left half, and it passes through the center of the body. The Sagittal plane passes through the body, parallel with the median plane. The Coronal plane passes through the body at right angles to the sagittal plane from side to

side. The transverse plane is a plane which is at right angles to the long axis of the body (Bryan, Davies, & Middlemiss, 1996; Tortora, 1986).

When collecting anthropometric data, identifying landmark becomes a key element in determining observer error. In an anthropometric based study, recorded measurements must be taken from common places of the body part, so that uniformity is achieved when measuring a body dimension. Those common points are defined as landmarks.

Determination of a landmark applies by providing a certain feature in the topography of the body surface. The tip of a finger is an example to such landmarks; or the landmark should be marked in a relation to skeletal architecture. Figure 2.2 shows the main landmarks:

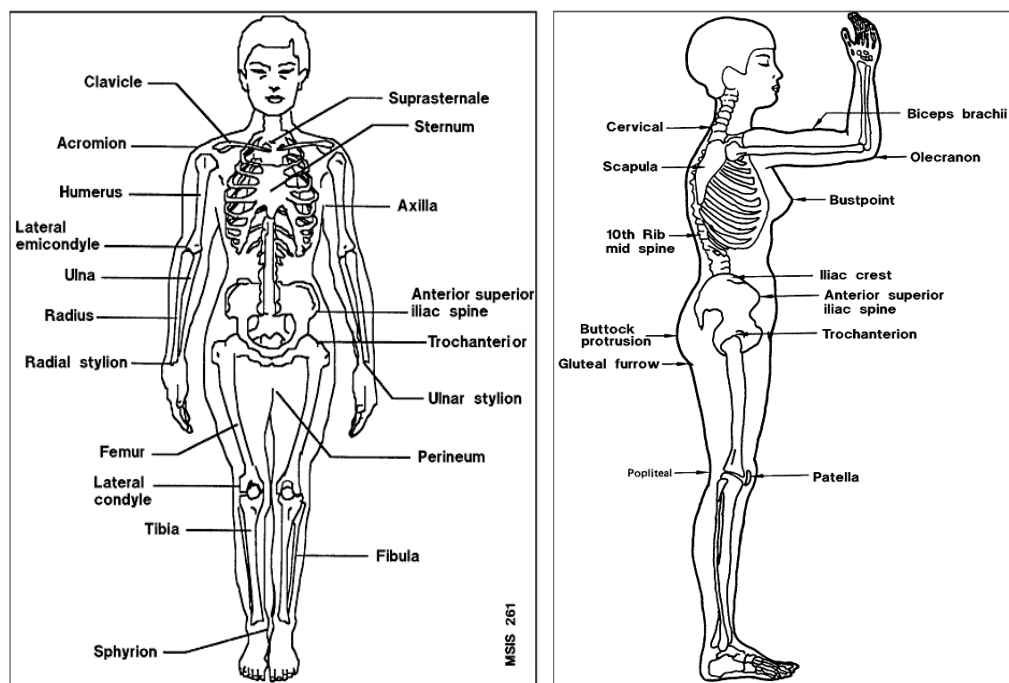


Figure 2.2. Selected skeletal landmarks used to define traditional anthropometric measurements (NASA-STD-3000, 1981).

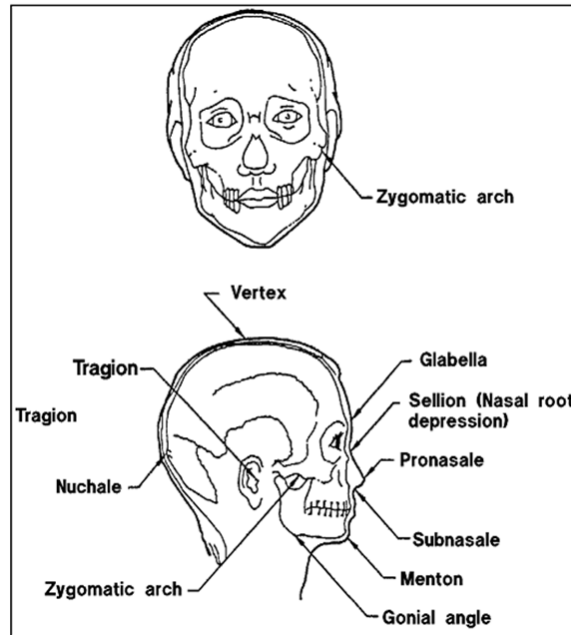


Figure 2.2 (cont.). Selected skeletal landmarks used to define traditional anthropometric measurements (NASA-STD-3000, 1981).

2.3.3. Types of Measurements

Anthropometric measurements are in relation with shape, size and composition of the different parts of the body. Basic anthropometric measurements include body mass, stature, breadth and depth dimensions, vertical and forward reaching positions and circumference at the hip, waist and chest.

There are more than 300 measurements in anthropometry (Simmons, 2001). In literature, a number of surveys included 37 of these measurements (Pheasant, 2000). On the other hand, according to the standards in ISO 7250 (the International Organization for Standardization) that provides a description of anthropometric measurements which can be used as a basis for comparison of population groups, this number is not enough to reflect the whole dimensions.

2.4. Anthropometric Design Approaches

There are four anthropometric design approaches (Ekşioğlu, 2013; Niebel and Freivalds, 2003):

2.4.1. Design for the individual

- It is used when there is a need for a customized personal product. Requires measuring anthropometric dimensions of a specific person.
- The best human-product match is achieved, whereas it is an expensive option.

2.4.2. Design for adjustability

- In this approach, some features of products/equipment or facilities are designed to fit a wide range of individuals.
- It provides adjustments (of the relevant measurements) to cover the range, usually from the 5th percentile female value to the 95th percentile male value of the whole population.
- It is mostly used in designing vehicle seats, tool supports, office chairs, desk heights, etc. Although it is the most preferable method, there is a trade-off with implementation cost.

2.4.3. Design for the extremes (Design for the smallest or the largest)

- There are some cases where a single design measurement becomes a limiting factor which may restrict the usage of product/facility for some people. For instance, a reach distance must be designed for the smallest person, which means, for a 5th percentile female arm reach. The distance of a control button from the operator could be determined in this way. By following this approach, nearly all males and 95th of all females are covered. In another case, i.e. in designing heights of doorways, the highest

(95th male) stature value of a design feature should accommodate 95th of all males and almost all females.

2.4.4. Design for the average

- It is known as the most quick and cheapest method. However, it is the least preferred one, since for instance when designing a supermarket counter desk for average, exceptionally tall males or very short females may have problems when using it.
- It is preferable when the situation involves a non-critical or non-frequent work. Snack machine controls and door knob height are examples of such designs.

2.5. Anthropometric Design Procedure

The procedure for designing products and facilities by using anthropometry could be explained in eight steps (Ekşioğlu, 2013; Kroemer, 1987):

- Step 1. Defining the relevant parameter which will be used in the design. Instances could be handle size of a tool, seat-to-roof dimensions in automobiles, and tool operation force.
- Step 2. The corresponding anthropometric measurement is chosen. In order to decide the seat-to-roof dimension, sitting height could be selected as the basis measurement. In similar way, hand breadth is used for handle length of a tool, and grip strength for tool operation force.
- Step 3. Definition of the target population to use the equipment or facilities. Examples could be children, pilots, women, different age groups, and people on wheelchair, Turkish adult population or Turkish military.
- Step 4. Determination of the design principle. It is concerned with the principles of anthropometric design; design for extreme, for adjustability, for average etc. For example, seat height should be designed for a range or tool operation force should accommodate the smallest extreme.

- Step 5. Selecting the select the percentage of the population to be accommodated where it is relevant. Values of 90% or 95% or other relevant percentage could be selected.
- Step 6. Extracting relevant values from anthropometric tables or other sources appropriate for the population.
- Step 7. Making the modifications if it is necessary (i.e., applying the correction factors when designing helmets, heavy clothing, shoe height.
- Step 8. Testing critical dimensions with a mock-up, user testing, a virtual model, or a computer model to make sure that they are compatible. An instance could be the legroom clearance height which is needed for sitting people who have long lower legs, and their legs may be very close to the height of the working surface determined from elbow height.

2.6. Anthropometric Studies

2.6.1. Studies in Other Countries

In this section, a number of anthropometric studies in other countries are reviewed.

The anthropometric measurements of Algerian women between 16-65 years have been presented by Mebarki & Davies (1990) in order to investigate the distribution of the anthropometric characteristics of female Algerian population. In total, 666 subjects took part in the study. Subjects were selected randomly and covered a mix of occupational groups for 23 body dimensions. The study also compares sitting height/stature ratio among several countries.

According to the results; age, occupation and geographical region were significant factors affecting anthropometric measurements.

In the survey of Bolstad et al. (2001), body mass and other twenty nine body measurements of Norwegian light industry and office workers were measured. Subjects were

equally divided into two groups of 20-29 years and 30-39 years respectively, both males and females. For female subjects, there was no significant difference neither in stature nor in body mass between these two age groups.

Santos *et al.* (2004) studied on elderly Chilean people aged between 60-99, and measured 8 body dimensions considering age and gender effects.

This study shows that body mass index values were significantly higher in women than in men, whereas women were significantly lighter and shorter than men in all age groups. For both women and men, each anthropometric variable was decreasing in average value with aging.

Barroso *et al.* (2005) studied 891 adult Portuguese industrial workers with ages ranging from 17 to 65 years old, and 399 of them were females. Twenty-four body dimensions were taken for each subject. Results showed that there is a high correlation between stature and other vertical dimensions. Moreover, some dimensions decrease, (e.g stature), while others (e.g abdominal depth) increase with aging. The results were also compared with those of UK, Poland and Holland populations.

Jinky Leilanie Del Prado-Leon (2007) conducted the study of anthropometric measurements of Filipino manufacturing workers. Subjects included 962 female and 843 male workers from manufacturing industry. 45 anthropometric measurements were taken for total of 1705 workers. According to the author, this study was a significant contribution to the Filipino labor force that is increasingly employed by both domestic and foreign multinationals.

Duan *et al.* (2007) studied on anthropometric measurements of Chinese elderly living in the Beijing area. 58 females and 50 males took part in the study, and there were 47 measurements in total. Required anthropometric data were essential part of the design since the increase in aged people resulted in the demand for health care and living products.

According to the results, mean stature of the subjects decrease with aging. There was very little difference in the dimensions around hip area between elderly males and females; therefore the study concluded that it was not necessary to consider gender difference in the design of related products. The results were also compared to those of Japanese elderly and of some other nations.

The study by Klamklay *et al.* (2008) was conducted with 50 female and 50 male students aged between 18-25 years. The objective was to investigate the anthropometric characteristics of southern Thai adults and to determine if upper south and lower south regions represented the southern Thai population. Moreover was to compare the existing anthropometric data with the study results. The study has shown that there were no significant differences for female population on body dimensions that are significantly different for males across regions of Thai population.

Datta *et al.* (2008) carried out the anthropometric survey for female farm workers from north eastern India. Age range was 18-60 years, and 400 subjects were measured for each of 76 body dimensions. Collected anthropometric data was compared to those of American, British, Chinese, Egyptian, Japanese, Korean, Mexican and Taiwanese female workers. The results have indicated that body dimensions measured had smaller values than dimensions of women from compared countries. The study was relevant for designing agricultural tools and equipment to be utilized by female agricultural workers which constituted 50.2 % of the total agricultural workforce in India.

The survey of Coqueiro *et al.* (2009) was a cross-sectional, population-based household survey. Selected anthropometric data were from a representative sample of elderly (60 years and older) subjects living in Havana, Cuba. In total, 1905 subjects (1197 women and 708 men) were examined for 8 anthropometric measurements and for BMI. The results showed that all anthropometric variables showed a decrease in mean values with aging in both women and men. The age of 70 years concluded to be the decisive moment for the main anthropometric differences observed. For body mass index (BMI) and triceps skin fold thickness, the values in the female subjects were higher than those in the male subjects.

Hanson et al. (2009) studied Swedish anthropometrics for products and workplace design. The study presents the anthropometrics of Swedish workforce, aged between 18 and 65 years, and compares the results of collected data with the data of 40 years earlier. 367 subjects were measured (262 females and 105 males) for 43 body dimensions. After comparing the new anthropometric data with the old, it was shown that weight, height, depth, and breadth, and length measurements have increased. The results indicated that there was a need for updating ergonomic recommendations and adjusting products and workplaces accordingly.

Chuan et al. (2010) researched the anthropometric data of the Singaporean and Indonesian populations. In total, 245 male and 132 female subjects from Indonesia, and 206 male and 109 female subjects (mostly university students) from Singapore were measured using 37 anthropometric measurements. Indonesian subjects were divided into two subgroups, comprising Indonesia citizens and Indonesia Chinese. Singapore data were divided into three subgroups; Singapore overall, Singapore citizens and Chinese ethnic subgroup. The author compared the collected data with the data from 1990 over a thousand Singaporeans, and made a comparison of the two samples obtained. The results showed that Indonesians have smaller dimensions than Singaporeans do in general.

Daruis *et al.* (2010) presented sitting anthropometry data for Malaysians focusing on seat fit parameters. Presented data offered additional data for seat design parameters, since there were only a few efforts for establishing anthropometric data in Malaysia. The study was carried out with 216 subjects (female and male) aged between 18 and 40 years for 16 important body dimensions to be used in seat design. The results indicated that the fit parameter dimensions were bigger than other Asians' 95th percentile values, however smaller than Thai and Filipino data compared in the study.

Grasgruber & Hrazdira (2012) measured the anthropometric characteristics of young Czech women and men and studied their relationship to the national sports potential. Since young Czech women and men had not been measured since 2001, this study filled the gap and provided additional information on physical characteristics of Czech population that were not

addressed in anthropological studies. The sample included 137 women and 142 men aged between 18 and 29 years old. The results shows that mean values of measured body dimensions both female and male subjects fit the long-term trend of secular height increase.

Fryar *et al.* (2012), collected 10 anthropometric measurements from 11,495 survey participants representing U.S population, with ages 20 years old and greater. The survey included 5,844 female subjects with ages 20+ years. Data are gathered from the National Health and Nutrition Examination Survey (NHANES) in 2007-2010, a stratified sample of the civilian U.S. population. Results provided the most recent anthropometric reference data for U.S. adults.

Alrashdan *et al.* (2014) investigated the anthropometry of Saudi Arabian female college students. Since many universities in Saudi Arabia have separate women campuses, only female students use classroom furniture, lab equipment and tools. The study focuses on the mismatch between the product design and Saudi female body dimensions and strength. 150 female students aged between 18 and 25 years old were measured for 32 body dimensions. In order to underline the product design mismatch, collected data were compared to those of Western and Asian populations including Turkish population. According to the results, Saudi and Turkish females have the same mean for some body dimensions and different means in other dimensions. The study also suggests that designers can use the data of one nation to design the products of other nation if two nations have the same mean value of concerning body dimension.

Summary of findings from the reviewed literature is as follows:

- Algerian female population has lowest sitting height ratio to stature compared to other female populations including German, British elderly women, French female drivers etc. meaning that Algerian females have longer legs than women from compared populations.

- For women working in light industry and women office workers in Norway, there was no significant difference in stature and weight between age groups, 20-29 years and 30-39 years respectively.
- Elderly Chilean population has a decrease in anthropometric dimensions with aging. Elderly women had higher BMI than elderly men do; they are also lighter and shorter than elderly man in all age groups.
- Almost all height, length and width dimensions of male Filipino manufacturing workers are higher than for females.
- The mean stature of the Chinese elderly living in Beijing area decrease with aging. Dimensions around hip area were similar considering elderly males and females, for those measurements gender differences were not significant.
- The southern and lower-southern Thai populations are different from the central Thai people in various body dimensions.
- Some vertical dimensions such as stature decrease with aging whereas some depth dimensions increase with ageing for Portuguese females.
- Female farm workers from north eastern India are in between short and long legged classification. The data show an increase in most body dimensions in the middle age (at 30s) before declining with increasing age.
- All anthropometric measurements decrease with aging for both elderly women and men living in Havana, Cuba. Body mass was greater in the youngest as compared with the oldest elderly among men and women. Moreover, mean BMI was greater in women than in men in each age group, and it was lower in the oldest than in the youngest individuals. Many of the anthropometric differences are more remarkably noticed from the age of 70 years.
- Swedish workforce population had 48 dimensions significantly different compared to the older data from 1969. For all females, 6 measurements of those 48 have decreased with time, and remaining had increased including stature.
- Indonesian population has smaller dimensions than Singaporean population does in general. Therefore it is deduced that geographical origin does have an effect on variation of anthropometry.

- Sitting anthropometry data for Malaysians showed that the fit parameter dimensions for seat design were higher than other Asians' 95th percentile values, however smaller than Thai and Filipino data.
- For young Czech women and men, mean values of measured body dimensions fit the long-term trend of secular increase.
- All Saudi females' mean body dimensions are smaller than American, Netherlands and Australian females' mean body dimensions. Comparing Saudi Arabian female college students with Turkish females, they both have the same mean for some body dimensions.
- Sampling method used in most studies was stratified sampling.
- Age and gender were selected as independent factors in most of the studies.
- Results showed that vertical and horizontal dimensions as well as width dimensions decrease with aging for studies in which age was selected as independent factor.

Information on some reviewed studies in foreign countries is shown in Table 2.4.

2.6.2. Studies for Population of Turkey

The first study related with anthropometry in Turkey was performed by Nafi Atuf Kansu in 1917 by examining students. The subjects consisted of 125 girls and 156 boys and the results were published in a journal called “Muallim” (Duyar *et al.*, 1996). The first comprehensive anthropometric study on Turkish population was realized in 1937 by State Statistics Institute (DIE). The survey was performed on 64000 women and men coming from 10 different regions of Turkey. In the study, the static anthropometric characteristics including stature, body mass, sitting height eye height, and arm span were collected (DIE, 1937). This study was followed by another study conducted by Çiner in 1960 on 1838 women aged between 20-40 years, and another study examining 915 Turkish soldiers in years 1960-61 (Çiner, 1960; Hertzberg *et al.*, 1963).

Table 2.4. Information of some studies about anthropometric measurements of people in foreign countries.

Source	Country	Sample type (n*)	Equipment / Number of Dimensions	Age range (yrs)	Independent factors	Age –groups (yrs)
Mebarki & Davies (1990)	Algeria	Stratified sampling (666 F)	A Harpenden Anthropometer, steel measuring tapes, weighing scales, and adjustable tools /23.	16-65	Age, occupation, geographical differences	Overall 16-25 26-35 36-45 45-65
Bolstad et al. (2001)	Norway	Light industry and office workers (199 F, 200 M)	Weighing scales, Harpenden anthropometers, measuring tapes, Digimatic sliding callipers, adjustable chairs and self-produced wooden /29.	20-39	Age, region, gender	Overall 20-29 30-39
Santos et al. (2004)	Chile	Stratified sampling (819 F, 411 M)	A Harpenden pocket stadiometer, a SECA platform scale, a broad-blade caliper, a chair /8.	60-99	Gender, age	60-64 65-69 70-74 75-80 80-84 >85
Barroso et al. (2005)	Portugal	Industrial workers (399 F, 492 M)	A portable digital camera, a tripod, an adjustable bench and a scale /25.	17- 65	Age, gender	Overall 18-20 20-29 30-39 40-49 50-65
Jinky Leilanie Del Prado-Leon (2007)	Philippines	Manufacturing industry workers (962 F, 843 M)	Tape measure, a goniometer, calipers and anthropometers /45.	N/A	N/A	Overall
Duan et al. (2007)	China	Stratified sampling (58 F, 50 M)	A weighing scale, two Martin-type anthropometers for standing and sitting, a sliding caliper, a spreading caliper, a foot measurer and a plastic tape /47.	Over 65	Age, gender	Overall 65-69 70-74 75+

Table 2.4. Information of some studies about anthropometric measurements of people in foreign countries (cont.).

Source	Country	Sample type (n*)	Equipment /Number of Dimensions	Age range (yrs)	Independent Factors	Age-group (yrs)
Klamklay et al. (2008)	Thailand	Students (50 F, 50 M)	Campbell Caliper, Segmometer, Anthropometric Tapes, Stadiometer /39.	18-25	Gender	Overall
Coqueiro et al. (2009)	Cuba	Stratified sampling (1197 F, 708 M)	Calipers and anthropometers /8.	Over 60	Age, gender	60-64 65-69 70-74 75-80 >80
Hanson et al. (2009)	Sweden	Stratified sampling (262 F, 105 M)	Two measuring tapes, a caliper, a digital weight scale, VITUS/Smart 3D body scanner /43.	18-65	Age, gender, region, occupation	18-29 30-39 40-49 50-59 60-65
Chuan et al. (2010)	Indonesia Singapore	Stratified sampling (241 F, 451 M)	A Campbell caliper 20, a Campbell caliper 10, a segmometer, a headboard, an anthropometric measuring tape, a weighing scale, meter scales and small stools /37.	18-45	Gender, region	Overall
Daruis et al. (2010)	Malaysia	Stratified sampling (95 F, 121 M)	An anthropometer, a meter ruler, calipers, and a measuring tape /16.	18-40	Gender, type of seat	Overall 18-25 26-40
Grasgruber & Hrazdira (2012)	Czech Republic	Stratified sampling (137 F, 142 M)	N/A	18-29	Gender, BMI	Overall
Fryar et al. (2012)	U.S.A	Stratified sampling (5844 F, 5651 M)	A digital floor scale, a wall-mounted stadiometer, a measuring tape, and a skinfold caliper /10.	20+	Age, gender, ethnicity	Overall 20-29 yrs 30-39 yrs 40-49 yrs 50-59 yrs 60-69 yrs 70-79 yrs 80+ yrs

Table 2.4. Information of some studies about anthropometric measurements of people in foreign countries (cont.).

Source	Country	Sample type (n*)	Equipment /Number of Dimensions	Age range (yrs)	Independent Factors	Age-group (yrs)
Alrashdan et al. (2014)	Saudi Arabia	Stratified sampling (150 F)	Two calipers, a segmometer, a headboard, measuring tapes, and a digital scale/33.	18-25	N/A	Overall

The study by Özok (1981) was about measuring 50 body dimensions of 1000 industrial workers from different industrial facilities. Relevant data was collected by simple random sampling method and was divided into nine age groups. Results of this study showed that the mean stature of Turkish men was 168.08 cm and mean stature increased by 0.7 cm in every ten years and mean weight increased by 1.05 kg.

Kayış and Özok (1991) measured 5109 army men aged between 18-26 years coming from a wide range of geographical areas. Selection of subjects was made with random sampling method for 51 anthropometric measurements.

Another study conducted by Kayış and Özok (1991) was performed on 3584 children aged between 6-13 years for 13 measurements. Age groups consisted of 8 single ages from 6 to 13. Data was collected by simple random sampling method and the research recommended on design of school furniture.

Gönen et al.(1991) studied on anthropometry of Turkish women by collecting 17 sitting and standing measurements from 100 women aged between 20-45 years; 95 women aged between 60-74 years and residents of rural and urban areas of Turkey. Descriptive statistics presented in the study showed that average stature was 156.49 cm and average weight was 67.40 kg for the whole population.

In 1995 Yorulmaz et al. investigated some body indexes in 1445 Turkish adults. In order to calculate those indexes, 4 measurements were taken for each subject. Those measurements were stature, weight, and waist and hip circumferences. From the calculated indexes, BMI values showed that more women were present in overweight BMI group.

Another study performed by Gültekin (2004) included 610 females and 812 males aged between 18-90 years living in Ankara. Subjects were coming from seven regions of Turkey and there were 9 age groups with 5 years age range. Results of this study showed that there was a secular trend in stature with an increase of 3 cm for adults over the past decade.

Yardımcı and Özçelik (2006) measured 650 adult women living in Gölbaşı, Ankara for 11 anthropometric measurements using stratified sampling method. Age range was 20-65+ years. BMI classification of the study has shown that most women (38.9 % of all subjects) were obese, and the study has concluded that BMI, marital status, smoking habit, menopause, exercise, body stature and eating habit were important factors affecting anthropometric measurements.

A comprehensive study performed by Güleç et al. (2006) included 1050 women and 1050 men between ages 20-65 from 14 provinces of Turkey for 37 anthropometric measurements. The study indicated that average sitting height for women and men in Turkey is statistically higher than European and American populations.

In another study, Burdurlu et al. (2006) measured 668 children aged between 12-15 years living in Ankara. For each subject, 5 measurements in standing posture and 18 measurements in sitting posture were taken. The study includes a regression analysis, and the results have shown that stature was found to be positively correlated with other body dimensions. Moreover, girls had higher dimensions in all ages compared to boys in the study.

Neyzi et al. (2008) studied on 4493 Turkish children aged from 3 months to 17 years by measuring body mass, stature, head circumference and calculated BMI values for each subject. Results have shown that Turkish children coming from higher socioeconomic status had similar values of stature with children from same age group in USA. Moreover, it was concluded that there was a secular increase in height for children.

The study by Iseri and Arslan (2009) was conducted by estimating 37 anthropometric measurements of Turkish population. Estimations of measurements were done by the ratio scaling technique; Çiner's (1960) data on female adults and Kayış and Özok's (1989) data on male adults were selected as reference populations in the study. Then, a survey on 2263 males and 1942 females from all regions of Turkey was conducted in 2007. The survey data was used in order to estimate those 37 measurements. The study investigated the age and region effect on weight and stature. Stature was found to decrease with age in both men and women; whereas weight was found to increase up to age of 50's

and decrease afterwards. Region and gender were also significant factors in determining anthropometric dimensions according to the results.

In the study of Karadağ et al. (2010) with 551 subjects aged between 19 and 97 years, knee height were measured for each subject for deriving predictive equations (≤ 50 years of age) after performing linear regression analysis according to the gender. Then, derived equations were used to estimate stature of elderly subjects. Among all cases, 60.3 % were <60 years (with mean: 48.75); 39.7 % of the cases were >60 years (with mean: 69.51). Estimated BMI (EBMI) measurements in the females and males >60 years were in average 1.23 kg/m^2 and 0.92 kg/m^2 higher than their real BMIs, respectively.

Koçtürk and Avcıoğlu (2010) investigated the anthropometric measures of women working in rural areas of Ankara in order to determine the appropriateness of the driver seats of the tractors to the measured dimensions. Therefore, 100 female subjects aged between 20-40 years took part in the study with 30 body dimensions. The study compares the measurements with those of German population and concludes that 12 measurements including chest depth, stature, sitting and standing eye height, shoulder height, hip breadth, sitting height, elbow height had lower significant average values than the values of compared population.

The most recent anthropometric data of Turkish women has been provided in a pilot study by Cengiz (2014). In the study, 225 females aged 18+ years were selected to participate with 56 body dimensions. All anthropometric measurements were taken according to ISO 7250. The results of this study indicated that these five factors provide a general description of human body shapes for the Turkish female population: "corpulence", "length of body parts", "upper body length", "length of arm" and "hip-thigh region".

Reviewed studies for the female population of Turkey provide the following main findings:

- Studies which did not use any estimation method used only traditional anthropometric measurement techniques.
- No study included all required anthropometric dimensions for various industries.

- Only the study by Cengiz (2014) took most of the body measurements provided in ISO standards into consideration.
- Age and gender significantly affects body mass and stature of Turkish females.
- BMI and geographic region of Turkey were also found to be significant factors in some studies.
- However job-group effect on anthropometric measurements was not analyzed in details.
- There is a secular increasing trend in average body mass and stature of Turkish women since 1937.
- Some studies selected regression analysis as the estimation method in order to provide updated values of body dimensions.
- Most of the studies did not clearly provide the sampling method used in detail; however almost all studies used simple random sampling method to determine the distribution of subjects. Table 2.5 shows the sample types, equipment used, age ranges and analyzed factors of some reviewed studies.

Table 2.5. Information of some studies about anthropometric measurements of Turkish subjects.

Source	Sample type (n*)	Equipment /Number of Dimensions	Age range (yrs)	Independent Factors	Age – groups (yrs)
Özok (1981)	Industrial workers (1000 M)	Measurement platform designed by Özok et al /50.	16-60	Age	16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60
Kayış and Özok (1991)	Soldiers (5109 M)	A standard GPM anthropometer and an adjustable rigid right-angled seat /51.	18-26	Age	18-26
Kayış and Özok (1991)	Children (1800 F 1784 M)	N/A /13.	6-13	Region, social status	6 (both genders) 7 (both genders) 8 (both genders) 9 (both genders) 10 (both genders) 11 (both genders) 12 (both genders) 13 (both genders)
Yorulmaz et al. (1995)	Stratified sampling (676 F, 769 M)	Tape measure, weighing scale /4.	(Avg ± sd) 22.99 ±7.25 (women) 22.18±7.28 (men)	N/A	Overall
Gültekin (2004)	Stratified sampling (610 F, 812 M)	A martin type anthropometer, a tape measure, a pedometer, and Harpenden skinfold caliper /16.	18-65+	Age, gender	18-24 (both genders) 25-39 (both genders) 30-34 (both genders) 35-39 (both genders) 40-44 (both genders) 45-49 (both genders) 50-54 (both genders) 55-64 (both genders) 65+ (both genders)
Yardımcı and Özçelik (2006)	Stratified sampling (650 F)	A hand held scale, tape measure, Holtain skinfold caliper, measuring cylinder /11.	20-65+	Age	<25 35-44 45-54 55-64 65+

Table 2.5. Information of some studies about anthropometric measurements of Turkish subjects (cont.).

Source	Sample type (n*)	Equipment /Number of Dimensions	Age range (yrs)	Independent Factors	Age – groups (yrs)
Güleç et al. (2006)	Stratified sampling (1050 F, 1050 M)	Antropometer /36	20-65	Age, region	20-65
İşeri and Arslan (2009)	Estimation (2263 M 1942 F)	A digital weight scale, tape measure /37.	20- 85	Age, region	20-24 (both genders) 25-29 (both genders) 30-34 (both genders) 35-39 (both genders) 40-44 (both genders) 45-49 (both genders) 50-54 (both genders) 55-59 (both genders) 60-79 (both genders)
Koçtürk and Avcioğlu (2010)	Stratified sampling (100 F)	Anthropometer /30.	20-40	N/A	Overall
Eren (2012)	Stratified sampling (250 M)	Stadiometer, Sitting height table,grid board, weighing scale, anthropometre, caliper, measuring tape, cylindrical handle/ 65	18-70	Age, BMIP,occupation, region	18-29 30-39 40-49 50-59 60-70

3. RATIONALE AND OBJECTIVES OF THE STUDY

3.1. Rationale behind the Study

Anthropometric data of the populations are needed for many design applications ranging from consumer products to vehicle and workspace designs. Anthropometric measures may vary across world populations. Available anthropometric data of female population of Turkey are insufficient in many aspects to satisfy the needs of designers and industry. For example, in most studies, sampling approach did not cover all regions of Turkey. Some others did not consider all the dimensions needed for various designs. Therefore, it is a need to carry out a comprehensive and statistically sound anthropometric study on the female population of Turkey.

3.2. Objectives of the Study

The objectives of this study are specified as follows, based on the rationale above:

- (i) Develop an up-to-date anthropometric database of adult female population of Turkey which meets the needs of most of the application areas,
- (ii) Study the effects of occupation type and age on body dimensions and
- (iii) Compare the estimated anthropometric dimensions of the adult female population of Turkey with the past data of population of Turkey, and the population of several other countries.

4. METHODS

The methodology followed to accomplish the objectives are covered in this chapter.

4.1. Phases of the Study

Following flow chart summarizes the phases of this study (Figure 4.1):

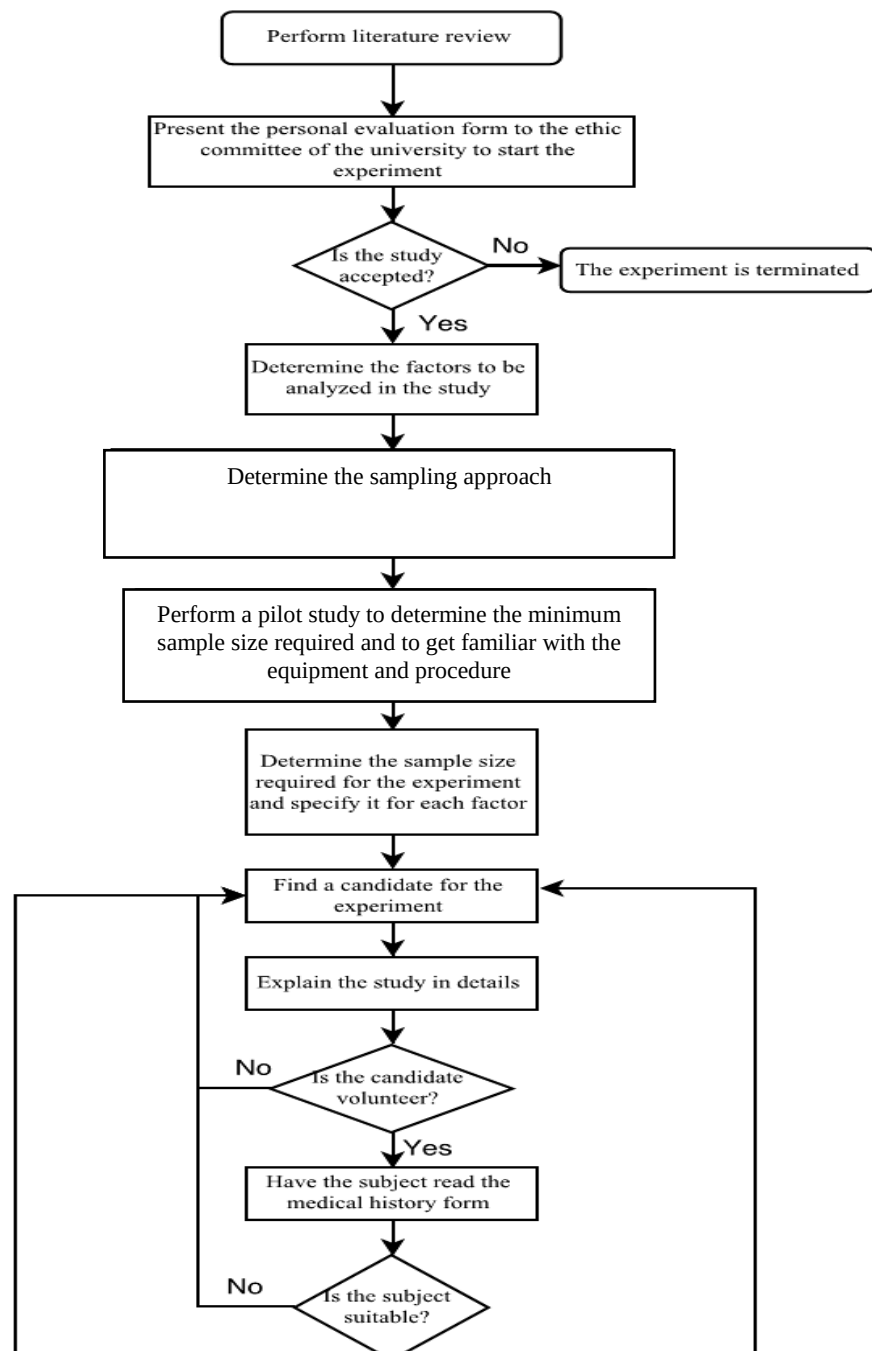


Figure 4.1. Flow chart for the study procedure.

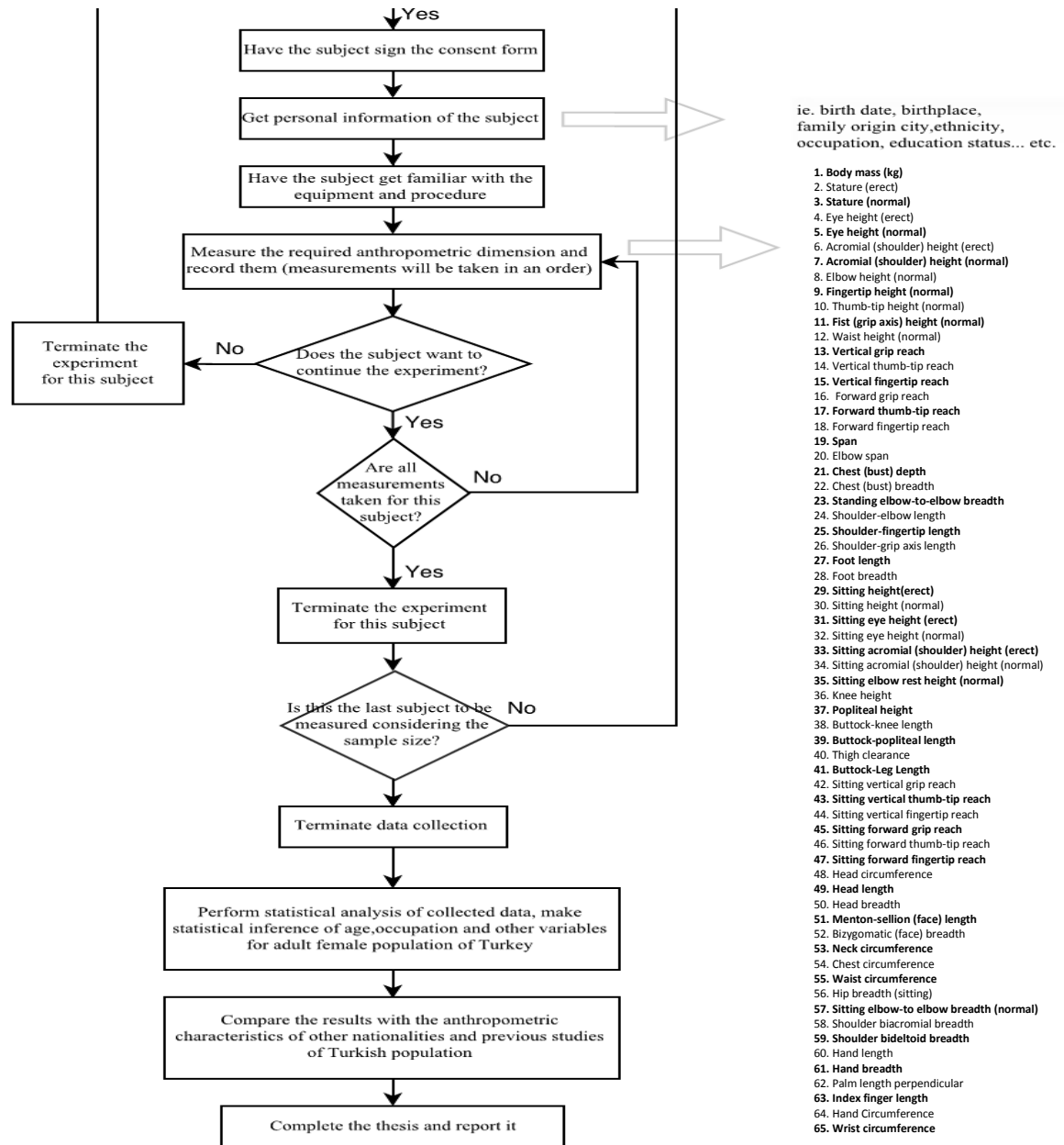


Figure 4.1. Flow chart for the study procedure (cont.).

4.2. Measurements

Anthropometric measurements used in the study were selected considering the needs of various industries such as workspace design, product design, clothing and architectural design. Therefore, 65 anthropometric measurements including the dimensions presented in ISO standards were studied. Table 4.1 shows the types of each body measurement in the study. Explanations of each dimension are provided in detail in table 4.2, and measurements are demonstrated all together in figure 4.2.

Table 4.1. Types of the anthropometric measurements.

No	Anthropometric measurements	Type	No	Anthropometric measurements	Type
1	Body mass (kg)	Static	24	Shoulder-elbow length	Static
2	Stature (erect)	Static	25	Shoulder-fingertip length	Static
3	Stature (normal)	Static	26	Shoulder-grip axis length	Static
4	Eye height (erect)	Static	27	Foot length	Static
5	Eye height (normal)	Static	28	Foot breadth	Static
6	Acromial (shoulder) height (erect)	Static	29	Sitting height(erect)	Static
7	Acromial (shoulder) height (normal)	Static	30	Sitting height (normal)	Static
8	Elbow height (normal)	Static	31	Sitting eye height (erect)	Static
9	Fingertip height (normal)	Static	32	Sitting eye height (normal)	Static
10	Thumb-tip height (normal)	Static	33	Sitting acromial (shoulder) height (erect)	Static
11	Fist (grip axis) height (normal)	Static	34	Sitting acromial (shoulder) height (normal)	Static
12	Waist height (normal)	Static	35	Sitting elbow rest height (normal)	Static
13	Vertical grip reach	Dynamic	36	Knee height	Static
14	Vertical thumb-tip reach	Dynamic	37	Popliteal height	Static
15	Vertical fingertip reach	Dynamic	38	Buttock-knee length	Static
16	Forward grip reach	Dynamic	39	Buttock-popliteal length	Static
17	Forward thumb-tip reach	Dynamic	40	Thigh clearance	Static
18	Forward fingertip reach	Dynamic	41	Buttock-leg length	Dynamic

Table 4.1. Types of the anthropometric measurements (cont.).

19	Span	Dynamic	42	Sitting vertical grip reach	Dynamic
20	Elbow span	Dynamic	43	Sitting vertical thumb-tip reach	Dynamic
21	Chest (bust) depth	Static	44	Sitting vertical fingertip reach	Dynamic
22	Chest (bust) breadth	Static	45	Sitting forward grip reach	Dynamic
23	Standing elbow-to-elbow breadth	Static	46	Sitting forward thumb-tip reach	Dynamic
47	Sitting forward fingertip reach	Dynamic	57	Sitting elbow-to elbow breadth (normal)	Static
48	Head circumference	Static	58	Shoulder biacromial breadth	Static
49	Head length	Static	59	Shoulder bideltoid breadth	Static
50	Head breadth	Static	60	Hand length	Static
51	Menton-sellion (face) length	Static	61	Hand breadth	Static
52	Bizygomatic (face) breadth	Static	62	Palm length perpendicular	Static
53	Neck circumference	Static	63	Index finger length	Static
54	Chest circumference	Static	64	Hand Circumference	Static
55	Waist circumference	Static	65	Wrist circumference	Static
56	Hip Breadth (sitting)	Static			

Table 4.2. Basic anthropometric measurements and their definitions (ISO 7250-1, 2008; Pheasant, 2000; Eastman Kodak Company, 1983; Lohman *et al.*, 1988; The National Academies Press, 2004; Peebles and Norris, 1998).

STANDING POSITIONS (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
1. Body weight (in kg)	Total mass (weight) of the body.	Person wears minimal clothing. Shoes are off. Person stands on the middle of the scale with feet close and arms on the side close to the body. Person stands still, looking straight ahead.	Used in the design of seated workplaces in which body mass is an important parameter.	Weighing scale	
2. Stature (erect)	Vertical distance from the floor to the highest point of the head while standing erect, while holding the full breadth.	Experimenter has to lower the headboard to the highest point of the head. Make sure the hair is compressed. Also, heels together with toes are pointing out about 60 degree angle and heels are touching on the base of the vertical back board of the stadiometer.*	Used for vertical clearances in workplaces or in locating equipment to avoid head collisions.	1. The Harpenden Stadiometer 2. Grid Board**	
3. Stature (normal)	Vertical distance from the floor to the highest point of the head while breathing normally.				
4. Acromial (shoulder) height (erect)	Vertical distance from the floor to the bony tip of the shoulder (acromion) while standing erect and holding the full breadth.	Subject stands with feet together, looking ahead. Shoulders are relaxed, with arms hanging freely.	Used for maximum height location of controls or perform other assembly or packing tasks which cause muscle fatigue.	1. The Harpenden Stadiometer 2. Grid Board	
5. Acromial (shoulder) height (normal)	Vertical distance from the floor to the bony tip of the shoulder (acromion) breathing normally.				

* : Feet should be in this position for all standing measurements.

** : Produced in Boğaziçi University Ergonomics Laboratory.

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

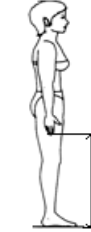
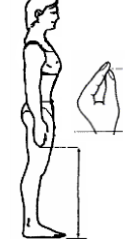
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
6. Eye height (erect)	Vertical distance from the floor to the outer corner of the eye while standing erect with full breathing.	Subject stands with feet together, looking ahead. Shoulders are relaxed, with arms hanging freely.	Used for locating visual displays.	1. The Harpenden Stadiometer 2. Grid Board	
7. Eye height (normal)	Vertical distance from the floor to the outer corner of eye, breathing normally.				
8. Elbow height (normal)	Vertical distance from the floor to the lowest bony tip point of the bent elbow, breathing normally.	Subject stands relaxed with feet together, looking ahead. Upper arm hangs freely downwards, with forearm flexed at 90 degree angle to it.	Used for workplace in which it is important for objects not to have to bend at the waist or hips, reducing the potential for muscle fatigue.	1. The Harpenden Stadiometer 2. Grid Board	
9. Fingertip height (normal)	Vertical distance from the floor to the tip of the middle finger, breathing normally.	Subject stands relaxed with feet together, looking ahead, hand and finger held straight down beside the body.	Used for workplace place in which it is important for objects to be handled or control operated without having to bend the knees.	1. The Harpenden Stadiometer 2. Grid Board	
10. Thumb-tip height (normal)	Vertical distance from the floor to the thumb-tip, breathing normally.	Subject stands relaxed with feet together, looking ahead, the fingers closes to each other as seen in the figure.		1. The Harpenden Stadiometer 2. Grid Board	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

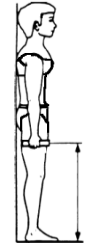
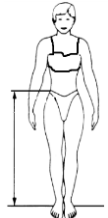
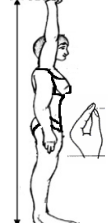
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
11. Fist (grip axis) height (knuckle height) (normal)	Vertical distance from the floor to the grip axis of the fist. In other words, it is vertical distance from the floor to the knuckle of the middle finger, breathing normally.	Subject stands relaxed with feet together, looking ahead, the arms hanging straight at the side.	Used for workplace place in which it is important for objects to be handled or control operated without having to bend the knees.	1. The Harpenden Stadiometer 2. Grid Board 3. Handle Diameter	
12. Waist height (normal)	Vertical distance from the floor to the anterosuperior iliac spine (the most downward-directed point of the iliac crest), breathing normally.	Subject stands relaxed with feet together, looking ahead.	Used for workplace place in which it is important for objects to be handled below waist level.	1. The Harpenden Stadiometer 2. Grid Board	
13. Vertical grip reach	Vertical distance from a vertical surface to the grip axis of the hand while the subject is standing and holding cylinder can handle with a diameter of 3.55 cm.	Subject stands erect, weight evenly balanced, with the arm extended vertically above the head.	Used for defining how high an overhead control can be.	1. The Harpenden Stadiometer 2. Grid Board 3. Handle Diameter	
14. Vertical thumb-tip reach	Vertical distance from the floor to the thumb-tip vertically while the subject is standing.	Subject stands erect, weight evenly balanced, with the arm extended vertically above the head.		1. The Harpenden Stadiometer 2. Grid Board	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

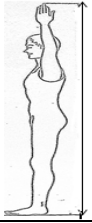
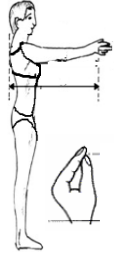
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
15. Vertical fingertip reach	Vertical distance from the floor to the tip of the middle finger while the subject is standing and reaching.	Subject stands erect, weight evenly balanced, with the arm extended vertically above the head and hand and fingers held straight.	Used for defining how high an overhead control can be.	1. The Harpenden Stadiometer 2. Grid Board	
16. Forward grip reach	Horizontal distance from a vertical surface to the grip axis of the hand while the subject leans both shoulder blades against the vertical surface.	Subject stands erect, the arm and hand stretched horizontally in front of them. Subjects hold a cylinder diameter of 3.55 cm.	Used for defining how far forward from a fixed structure, such as a wall, a person who is strained from leaning forward can reach for controls.	1. The Harpenden Stadiometer 2. Grid Board 3. Handle Diameter	
17. Forward thumb-tip reach	Horizontal distance from a vertical surface to the middle of the pad of the thumb where contact is made in a pinch-grip while the subject leans both shoulder blades against the vertical surface.	Subject stands erect, the arm and hand stretched horizontally in front of them.		Grid Board	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

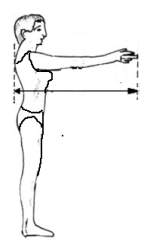
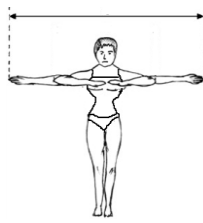
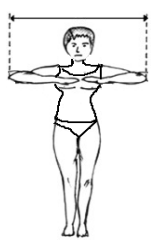
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
18. Forward fingertip reach	Horizontal distance between back of the shoulders to the tip of the middle finger while the subject is standing.	Subject stands erect, the arm and hand stretched horizontally in front of them.	Used for defining how far forward from a fixed structure, such as a wall, a person who is strained from leaning forward can reach for controls.	Grid Board	
19. Span	The maximum horizontal distance between the tips of the middle fingers when both arms are stretched out sideways.	Subject stands erect, feet together and the arms outstretched on other side in line with the shoulders.	Used for defining the maximum reach through two arms in the design of workplaces.	Grid Board	
20. Elbow span	The horizontal distance between the tips of the elbows when both upper limbs are stretched out sideways and the elbows are fully flexed so that the fingertips touch chest.	Subject stands with the upper arms spread horizontally on each side of the body and the elbows are flexed to bring the hands in to touch the chest.	Used for defining the horizontal distance between two elbows in the design of workplaces.	Grid Board	
21. Chest (bust) depth	Horizontal depth of the torso measured at the chest at the level of the nipples.	Subject stands fully erect, arms hanging freely downwards. Females wear their usual brassiere.	Used for defining the horizontal depth of torso in the design of workplaces.	Large Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

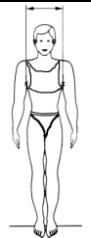
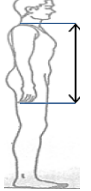
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
22. Chest (bust) breadth	Horizontal breadth of the torso measured at the chest at the level of the nipples.	Subject stands erect, arms held slightly away from the sides, breathing quietly.	Used for defining the horizontal breadth of torso in the design of workplaces.	Large Anthropometer	
23. Standing elbow-to-elbow breadth (normal)	Horizontal distance between the outer borders of the elbows.	Subject stands with the elbows flexed to the 90 degrees, the upper arms hanging vertically at the sides.	Used for defining the horizontal distance between elbows in the design of workplaces.	Large Anthropometer	
24. Shoulder-elbow length	Vertical distance from the bony tip of the shoulder (acromion) to the underside of the elbow.	Subject stands, with the upper arm vertical and the elbow flexed to 90 degrees.	Used for defining the level at which shoulder abduction.	Large Anthropometer	
25. Shoulder-fingertip length	Vertical distance from the bony tip of the shoulder (acromion) to the tip of the middle finger.	Subject stands, with the upper arm vertical flexed 180 degrees.	Used for defining the level at which the person can reach and control an equipment.	Large Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

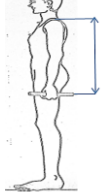
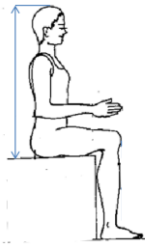
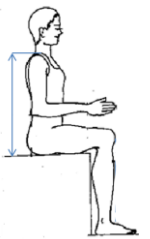
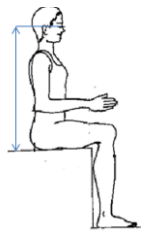
SEATED POSITIONS (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
26. Shoulder-grip axis length	Vertical distance from the bony tip of the shoulder (acromion) to the grip axis.	Subject stands, with the upper arm vertical flexed 180 degrees.	Used for defining the level at which the person can reach and control an equipment.	1. Large Anthropometer 2. Handle Diameter	
27. Sitting height (erect)	Vertical distance from a horizontal sitting surface to the highest point of the head while sitting erect, breathing fully.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees.	Used for defining the vertical clearance needed for seated work.	The Harpenden Sitting Height Table	
28. Sitting height (normal)	Vertical distance from a horizontal sitting surface to the highest point of the head, breathing normally.				
29. Sitting acromial (shoulder) height (erect)	Vertical distance from a horizontal sitting surface to the bony tip of the shoulder (acromion), sitting erect.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees.	Used for defining the top of the torso for chair design.	1. The Harpenden Sitting Height Table 2. Grid Board	
30. Sitting acromial (shoulder) height (normal)	Vertical distance from a horizontal sitting surface to the bony tip of the shoulder, breathing normally.				
31. Sitting eye height (erect)	Vertical distance from a horizontal sitting surface to the outer corner of the eye, sitting erect, breathing fully.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees.	Used to define locations for visual displays in seated workplaces.	1. The Harpenden Sitting Height Table 2. Grid Board	
32. Sitting eye height (normal)	Vertical distance from a horizontal sitting surface to the outer corner of the eye, breathing normally.				

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
33. Sitting elbow rest height (normal)	Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at a right angle with the forearm horizontal, breathing normally and elbows are not touching to the body.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees.	Used for design of seated workplace height.	Large Anthropometer	
34. Knee height	Vertical distance from the floor to the highest point of the superior border of the patella.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The seat should be adjusted so that the subject can sit with the lower legs vertical, thighs horizontal and feet flat.	Used in the design of seated workplace heights.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	
35. Popliteal height	Vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee, bent at right angles.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The seat should be adjusted so that the subject can sit with the lower legs vertical, thighs horizontal and feet flat.	Used for defining seat height adjustability and footrest needs for seated workplaces.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	
36. Buttock-knee length	Horizontal distance from the foremost point of the knee-cap to the rearmost point of the buttock.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The seat should be adjusted so that the subject can sit with the lower legs vertical, thighs horizontal and feet flat.	Used for defining seat depth for chairs and minimum forward clearance for seated workplaces.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

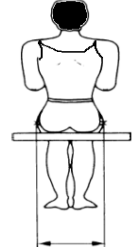
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
37. Buttock-popliteal length	Horizontal distance from the back point of the knee-cap to the rearmost point of the buttock.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The seat should be adjusted so that the subject can sit with the lower legs vertical, thighs horizontal and feet flat.	Used for defining seat depth for a chair to ensure that pressure on the underside of the thigh is not excessive.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	
38. Buttock-Leg Length	Horizontal distance from the most posterior part of the buttock to the sole of the foot.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The subject sits erect with one leg extended horizontally in front of them.	Used for defining maximum leg clearance for seated workplaces and for maintenance tasks where the person has to sit on the floor to do the task	1.The Harpenden Sitting Height Table 2.Measuring tape	
39. Thigh clearance	Vertical distance from the sitting surface to the upper, uncompressed, surface of the thigh where the thigh depth is greatest.	Subject sits, looking straight ahead, the elbows are flexed at 90 degrees. The seat should be adjusted so that the subject can sit with the lower legs vertical, thighs horizontal and feet flat.	Used in the design of seated work surface heights or in the selection of the adjustability levels of a chair.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	
40. Hip breadth (sitting)	Horizontal breadth of the body measured across the widest portion of the hips.	Subject sits erect and with the legs and feet together.	Used for defining seat widths and whole-body access port clearance.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

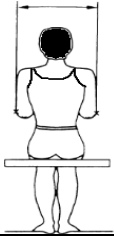
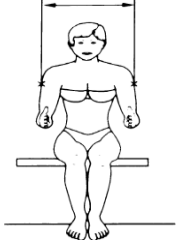
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
41. Sitting elbow-to elbow breadth (normal)	Maximum horizontal distance between the lateral surfaces of the elbow region, breathing normally. Upper arms are making about 15 degree angle with the body.	Subject stands with the elbows flexed to the 90 degrees, the upper arms hanging vertically at the sides.	Used for defining the horizontal distance between elbows in the design of workplaces.	1.The Harpenden Sitting Height Table 2.Large Anthropometer	
42. Shoulder biacromial breadth	Horizontal distance along a straight line from the bony tips of shoulders (acromion).	Subject sits erect with the arms flexed at 90 degrees, measuring from the behind the subject.	Used for defining whole-body clearance requirements for access ports.	1. The Harpenden Sitting Height Table 2. Large Anthropometer	
43. Shoulder bideltoid breadth	Horizontal distance across the maximum lateral protrusions of the right and left deltoid muscles.	Subject sits erect with the arms flexed at 90 degrees, measuring from the behind the subject.		1. The Harpenden Sitting Height Table 2. Large Anthropometer	
44. Sitting vertical grip reach	Vertical distance from a vertical sitting surface to the grip axis of the hand while the subject is sitting, holding cylinder handle diameter.	Subject sits erect, weight evenly balanced, with the arm extended vertically above the head.	Used for defining the maximum height at which controls should be located in overhead panels.	1. The Harpenden Sitting Height Table 2. Grid Board 3. Handle Diameter	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

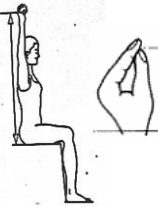
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
45. Sitting vertical thumb-tip reach	Vertical distance from a vertical sitting surface to the thumb-tip while the subject is sitting	Subject sits erect, weight evenly balanced, with the arm extended vertically above the head.	Used for defining the maximum height at which controls should be located in overhead panels.	1. The Harpenden Sitting Height Table 2. Grid Board	
46. Sitting vertical fingertip reach	Vertical distance from a vertical sitting surface to the tip of the middle finger of the hand while the subject is sitting.	Subject sits erect, weight evenly balanced, with the arm extended vertically above the head and hand and fingers held straight.	Used for defining the maximum height at which controls should be located in overhead panels.	1. The Harpenden Sitting Height Table 2. Grid Board	
47. Sitting forward grip reach	Horizontal distance from the wall to the grip reach while the subject is sitting, holding cylinder handle diameter.	Subject sits erect, the arm and hand stretched horizontally in front of them.	Used for defining how far forward from a fixed structure, such as a wall, a person who is strained from leaning forward can reach for controls while sitting.	1. The Harpenden Sitting Height Table 2. Grid Board 3. Handle Diameter	
48. Sitting forward thumb-tip reach	Horizontal distance from the wall to the thumb-tip reach while the subject is sitting	Subject sits erect, the arm and hand stretched horizontally in front of them.		1. The Harpenden Sitting Height Table 2. Grid Board	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

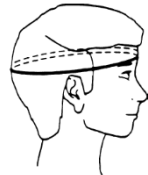
HEAD MEASUREMENTS (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
49. Sitting forward fingertip reach	Horizontal distance from the wall to the tip of the middle finger reach while the subject is sitting.	Subject sits erect, the arm and hand stretched horizontally in front of them.	Used for defining how far forward from a fixed structure, such as a wall, a person who is strained from leaning forward can reach for controls while sitting.	1. The Harpenden Sitting Height Table 2. Grid Board	
50. Head circumference	Maximum, approximately horizontal, circumference of head measured just above the eyebrows at the front and the most protruding portion of the back of head.	Subject sits, looking straight ahead, and hair should be compressed.	Used in head protective equipment design, such as helmets.	Measuring tape	
51. Head length	Horizontal distance along a straight line between the glabella (brow bridges) and the most protruding portion of the back of the head.	Subject sits, looking straight ahead, and hair should be compressed.		Small Anthropometer	
52. Head breadth	The maximum horizontal breadth of head above and behind the ears, where the head is broadest.	Subject sits, looking straight ahead, and hair should be compressed.	Used in the design of clothing and of protective equipment, such as respirators.	Small Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

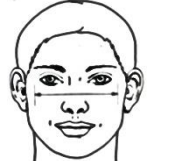
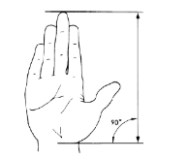
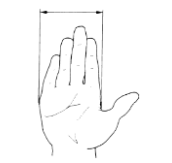
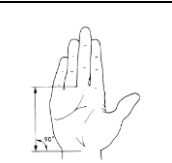
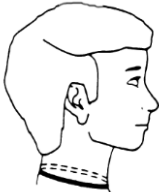
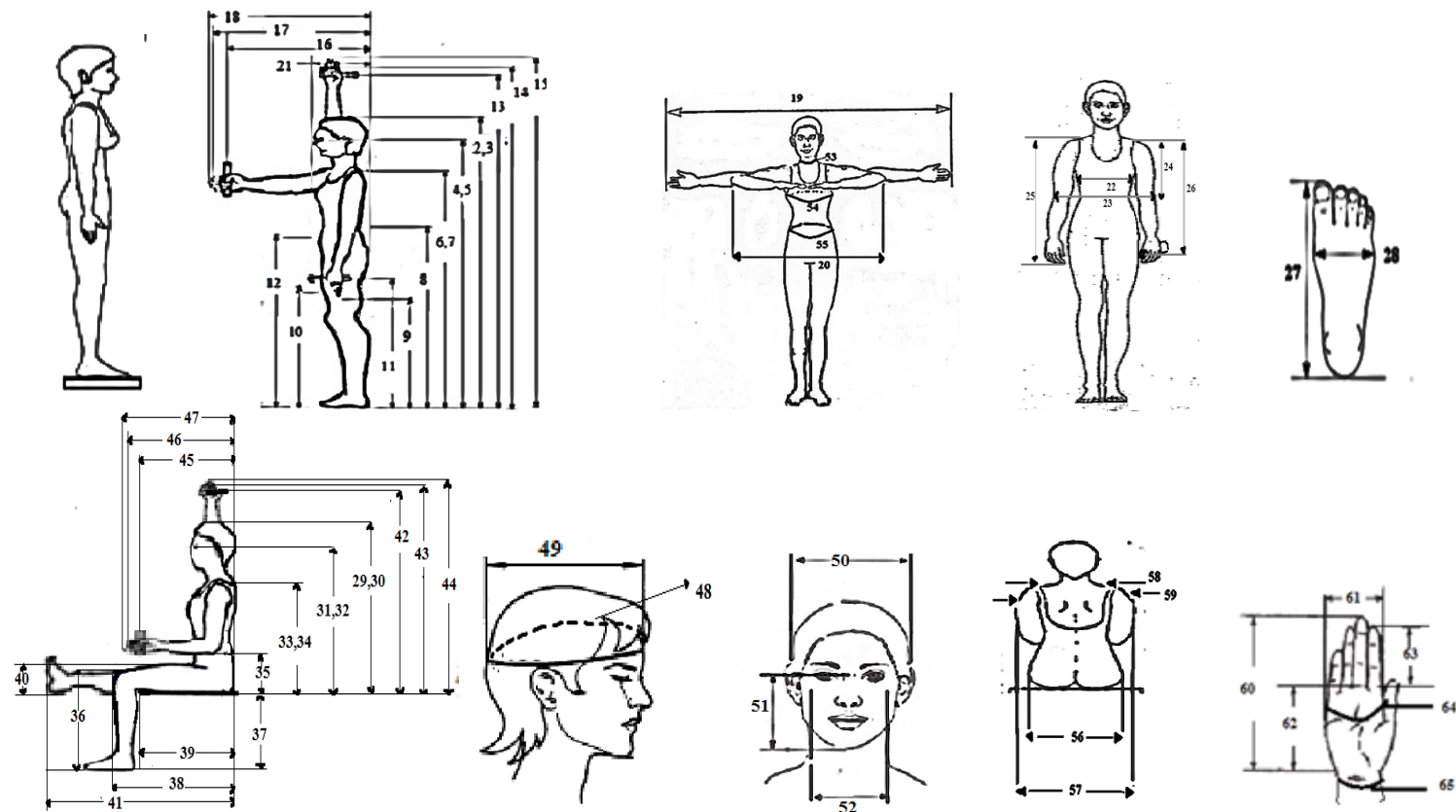
HAND MEASUREMENTS (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
53. Menton-sellion (face) length	Vertical distance from the bony tip of the chin to the depression (sellion) at the top of the nose, below the brow ridge.	Subject sits, looking straight ahead.	Used in design of protective equipment, such as masks.	Kumpas or Caliper	
54. Bizygomatic (face) breadth	The maximum horizontal breadth of the face between the broadest portions of the cheekbones, between the eyes and the ears.	Subject sits, looking straight ahead.	Used in eye protective equipment design, such as goggles.	Kumpas or Caliper	
55. Hand length	Perpendicular distance from a line drawn between the styloid processes to the tip of the middle finger.	Subject sits, and the hand and fingers should be held straight and flat, palm uppermost.	Used to define the working space of the hand in maintenance tasks and for hand tool design.	Kumpas or Caliper	
56. Hand breadth	Distance across the palm of the hand at the junction between the palm and the fingers, not including the thumb.	Subject sits, and the hand and fingers should be held straight and flat, palm uppermost.	Used to define clearances for the working hand and handle dimensions of tools.	Kumpas or Caliper	
57. Palm length perpendicular	Distance from the wrist crease to the crease at the base of the middle finger.	Subject sits, and the hand and fingers should be held straight and flat.	Used for hand tool design.	Kumpas or Caliper	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

FOOT MEASUREMENTS (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
58. Index finger length	Distance from the tip of the index finger to the base of the finger at the level of the skin web between it and the middle finger.	Subject sits, and the hand and fingers should be held straight and flat, palm uppermost.	Used to define the maximum depths of control buttons set inside equipment.	Kumpas or Caliper	
59. Hand Circumference	The circumference of the hand, measured around the palm at the junction between the palm and the fingers.	Subject sits, and the hand and fingers should be held straight and flat.	Used for hand tool design.	Measuring tape	
60. Wrist circumference	Circumference of wrist at the level of the wrist crease.	Subject sits, and the hand and fingers should be held straight and flat. This is a minimum measurement of wrist circumference.	Used for hand tool design.	Measuring tape	
61. Foot length	The maximum horizontal distance from the tip of the longest toe to the back of the heel.	Subject stands with their weight evenly balanced on both feet.	Used to define foot pedal dimensions and foot clearance at standing workplaces or around production machines.	Small Anthropometer	

Table 4.2. Basic anthropometric measurements and their definitions (cont.).

OTHER CIRCUMFERENCES (in cm)					
Measure	Definition	Measurement Details	Application Areas	Equipment	Figure
62. Foot breadth	The maximum horizontal distance across the widest point of the foot, perpendicular to the length of the foot.	Subject stands with their weight evenly balanced on both feet.	Used to define foot pedal dimensions and horizontal clearance at standing workplaces.	1. Small Anthropometer 2. Caliper	
63. Neck circumference	Circumference around the neck, halfway between the Adam's apple and the top of the breastbone.	Subject should stand; and pressure on the tape should be minimal to avoid discomfort.	Used in design of clothing and neck protective equipments.	Measuring tape	
64. Chest circumference	Maximum circumference, measured horizontally around the chest at the level of the nipples.	Subject stands erect, looking forwards, with shoulders relaxed and breathing quietly.	Used in design of clothing.	Measuring tape	
65. Waist circumference	Circumference measured horizontally at the level of the wrist (where the smallest abdominal circumference occurs).	Subject stands erect with the arms held slightly away from the sides of the body.	Used in design of clothing.	Measuring tape	



- 1: Body Mass, 2: Stature (erect), 3: Stature (normal), 4: Eye height (erect), 5: Eye height (normal), 6: Acromial (shoulder) height (erect), 7: Acromial (shoulder) height (normal), 8: Elbow height (normal), 9: Fingertip height (normal), 10: Thumb-tip height (normal), 11: Fist (grip axis) height (normal), 12: Waist height (normal), 13: Vertical grip reach, 14: Vertical thumb-tip reach, 15: Vertical fingertip reach, 16: Forward grip reach, 17: Forward thumb-tip reach, 18: Forward fingertip reach, 19: Span, 20: Elbow span, 21: Chest (bust) depth, 22: Chest (bust) breadth, 23: Standing elbow-to-elbow breadth, 24: Shoulder-elbow length, 25: Shoulder-fingertip length, 26: Shoulder-grip axis length, 27: Foot length, 28: Foot breadth, 29: Sitting height(erect), 30: Sitting height (normal), 31: Sitting eye height (erect), 32: Sitting eye height (normal), 33: Sitting acromial (shoulder) height (erect), 34: Sitting acromial (shoulder) height (normal), 35: Sitting elbow rest height (normal), 36: Knee height, 37: Popliteal height, 38: Buttock-knee length, 39: Buttock-popliteal length, 40: Thigh clearance, 41: Buttock-leg length, 42: Sitting vertical grip reach, 43: Sitting vertical thumb-tip reach, 44: Sitting vertical fingertip reach, 45: Sitting forward grip reach, 46: Sitting forward thumb-tip reach, 47: Sitting forward fingertip reach, 48: Head circumference, 49: Head length, 50: Head breadth, 51: Menton-sellion (face) length, 52: Bizygomatic (face) breadth, 53: Neck circumference, 54: Chest circumference, 55: Waist circumference, 56: Hip breadth (sitting), 57: Sitting elbow-to elbow breadth (normal), 58: Shoulder biacromial breadth, 59: Shoulder bideltoid breadth, 60: Hand length, 61: Hand breadth, 62: Palm length perpendicular, 63: Index finger length, 64: Hand circumference, 65: Wrist circumference.

Figure 4.2. Basic anthropometric measurements used in this study.

4.3. Equipment

Standard tools used for taking anthropometric measurements, for body mass, lengths, breadths and circumferences are given as following:

4.3.1. Holtain Harpenden Stadiometer

The Harpenden Stadiometer is a counter recording instrument with a counter balanced movement. It gives accurate and direct reading of a subject's height, to the nearest millimeter. The main frame of the instrument is made of light alloy angle and provided with adjustable wall brackets for mounting purposes. The wall brackets can be moved up and down easily. The stadiometer head-block operates via miniature ball-bearing rollers in order to ensure a movement which is free yet without cross-play. A high speed Veeder-Root counter on this stadiometer is used for taking most of standing measurements. The representation of the equipment is given in Figure 4.3.1.

4.3.2. Grid Board

The orthogonal two-piece gridline board, which had been produced at Boğaziçi University Ergonomics Laboratory, was used for taking most of the measurements in the study. Figure 4.3.2 shows the gridboard. Two wooden pieces sized 130 mm x 250 mm and 260 mm x 250 mm had been placed 90 degree angle with each others. The dimensions of the gridboard had been determined according to 99 % of population of Turkey provided in the previous studies. This equipment is used in order to measure almost all vertical dimensions as well as horizontal reach positions precisely and consists of an adjustable height seat to measure dimensions in sitting position, such as sitting height, sitting shoulder height, sitting forward grip reach etc. The grid board consists of an adjustable seat. Adjustments are made by adding or subtracting rectangular blocks of size of 36x43.5 cm with 1 cm thickness. The seat has 30 cm base height, and the adjustments are made until the subject had a 90-degree angle between the thigh and the calf, with feet resting firmly on the floor. In this study, sitting table dimensions had been determined considering the 1th and 99th percentile of population of Turkey provided in the previous studies. Figure 4.3.3 shows the adjustable height seat.

4.3.3. Anthropometers

The large anthropometer has a range of 0 mm to 600mm in 0.1 cm increments while the small one has a range of 0 mm to 300 mm. They are mostly used for measuring measuring long bone length, shoulder width, and chest depth for tracking growth. They use a spring-loaded ball bearing in a sliding C-shaped arm to provide precise measurements and are made of aluminum. Figure 4.3.4 illustrates large and small anthropometers.

4.3.4. Caliper

Calipers are used to measure the distance between two opposing sides of the subjects such as length and breadth measurement. The edges of the caliper need to be adjusted to fit across the points to be measured. Then, the caliper is removed, and the distance through the scales on the caliper is recorded. In this study, caliper was used to measure the external size of an object including hand length, hand breadth, and index finger length. The result on this equipment is read with a high degree of accuracy and repeatability. The equipment is shown in Figure 4.3.5.

4.3.5. Measuring Tapes

Two types of tape measures were used in this study in order to measure the circumferences. The large tape measure was used have a length of 3000 mm and was used for dimensions including neck, chest, and waist circumferences. Figure 4.3.6 shows the measuring tapes used in this study.

4.3.6. Cylindrical Handle

In this study, a wooden cylinder handle with about 3.55 cm diameter was used for measuring grip reach dimensions of subjects. Then, to evaluate grip anthropometric measurements, handle diameter was designed on 3.55 cm in diameter as can be seen Figure 4.3.g. The diameter design was made according to the instructions by Kong and Lowe (2005) who stated that the optimal handle diameter was 19.7% of the user's hand length.

a.



b.



c.



d.



e.



f.



g.



a: Holtain Harpenden Stadiometer. b: Grid Board. c: Adjustable height seat. d: Large and small anthropometers. e: Caliper. f: Measuring tapes.
g: Cylindrical handle

Figure 4.3. Equipment used in the study.

4.4. Sampling Approach

In order to accept subjects for the measurements, a medical history form was applied to each candidate. The form served for determining if the subject had any body limitations to participate to the study. Such limitations could be a defect on the body dimensions, deficiency in hand, a burned body part etc. Only people who did not have any body defect were allowed for the measurements. The form is provided in Appendix A.1.

Stratified sampling method was utilized, so that the study represents the whole adult female population of Turkey. By this context, subjects were stratified from all, considering participants with ages of 18 to 79 years old from 7 regions of Turkey and manual and non-manual job groups. Within each group, subjects were selected randomly.

Subjects living in the city of İstanbul and surrounding area contributed voluntarily to the study. According to the results of Turkish Statistical Institute (TÜİK) in 2014, the 21.7 % of people who is living in Istanbul are registered into same province while the registered address of 78.3 % of them are other provinces of Turkey. In other words, people whose family origins of people living in Istanbul come from every region of Turkey. Considering this information, it is assumed that the population of Istanbul approximately represents the population of Turkey due to its demographic characteristics.

According to the distribution of population of Turkey in 2014 presented by TÜİK, Table 4.3 represents the number of people in terms of province regions, and the distribution percentages are shown in Figure 4.4:

Table 4.3. Distribution of population of Turkey based on family origin (TÜİK, 2014).

Region	Population
Black Sea	14.493.823
Central Anatolia	13.280.435
Eastern Anatolia	11.137.229
Southeastern Anatolia	11.334.333
Aegean	8.045.602
Mediterranean	8.843.959
Marmara	10.042.244
Total*	77.177.625

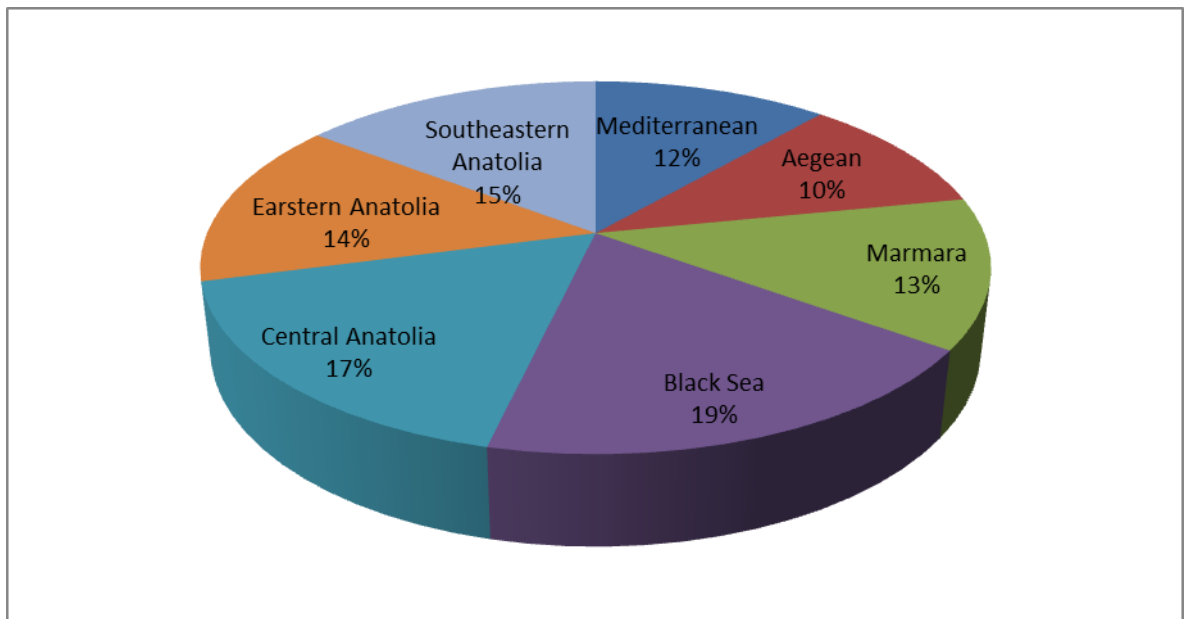


Figure 4.4. Distribution of family origin region of population of Turkey with respect to seven regions (TÜİK, 2014).

Sampling approach in the study included female subjects with father's family origin from anyone of the seven regions of Turkey. It was attempted to recruit subjects from seven regions with sample sizes to be equal as much as possible. Age grouping is an essential part of such studies, since age is an important factor affecting anthropometry. In most of studies such as Jeremic *et al.* (2013), and Taura (2011), there are age groups starting from 18 to 79 years considering the change in body dimensions. Therefore, age grouping was made in order to cover almost all representative adult ages; subjects were divided into 5 age groups as follows (in years): (18-29), (30-39), (40-49), (50-59) and (60-79). Number of people and their percentage in the age groups considering the total population and adult female population between 18 and 79 years in Turkey is shown in Table 4.4. According to Turkish Statistical Institute (2014) data of age distribution, there are 3,169,840 adult female people between 15 and 19 years of age. In order to obtain the number of people between 18 and 19 ages, it is assumed that there is a linear distribution between 15-19 aged female people. Therefore, 40% of this distribution is taken for 18-19 aged female people. Then, this age distribution is added into 19-24 and 25-29 aged adult female people distribution in order to obtain the number of female people between 18 and 29 years old as 7,433,545. Then, the age distribution of population of Turkey is shown in Figure 4.5.

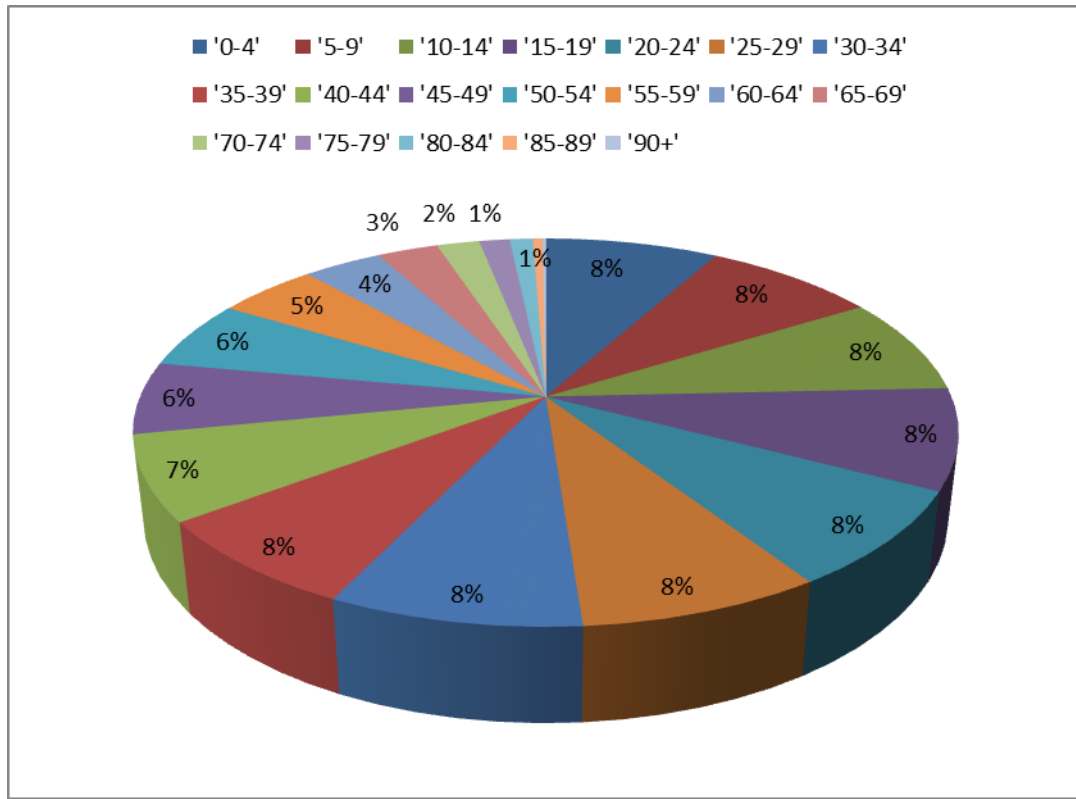


Figure 4.5. Age distribution of population of Turkey (TÜİK, 2014).

Table 4.4. Age-based distribution of total population of Turkey with female population statistics of the age groups between 18 and 79 years and their percentages (TÜİK, 2014).

Age-groups (in years)	Total population	Female population	Percentage of female population
18-29	12.536.662	7.433.545	27%
30-39	12.434.630	6.144.240	22%
40-49	10.184.599	5.042.800	18%
50-59	8.094.985	4.048.188	15%
Above 60	9.063.677	4.961.650	18%
Total	52.314.553	26.362.487	100%

Occupation grouping and social class influence anthropometry (Pheasant, 2000). After analyzing NHANES III survey, Hisaio *et al.* (2002) indicated the differences between occupational groups in United States showing that military personnel are stronger, larger and fitter than the civilians are. In literature, there are many studies, which take manual and non-manual workers as two occupational groups. Tanner (2010) explains most of these studies in details. Since findings of those studies show that job grouping affects anthropometric dimensions, occupations were grouped into two levels as manual and non-manual workers in order to analyze the job-group effect on the adult female population of

Turkey. This categorization was partly made by the help of the outcomes of ISCO-08 (2012).

4.4.1. Pilot Study

Before the actual study, a pilot study with randomly selected 100 adult female subjects was conducted. The sampling approaches used are explained in previous sections. The aims of pilot study were:

- (i) to get familiar with equipment and procedures of the study.
- (ii) to determine the mean and standard deviation needed to calculate the sample size for the actual study.

The overall mean and standard deviation of body dimensions for adult female subjects obtained from the pilot study are given in Table 4.5.

4.4.2. Sample Size Determination

Determining sample size is an important feature of any statistical analysis when the aim is to make inferences on the population. Calculating sample size is based on how much data we need to obtain sufficient statistical power. It must be large enough to give desired precision and small enough to reduce the expense of data collection.

ISO standards for establishing anthropometric databases give sample size calculation formula for normative data studies as the following (ISO 15535:2012):

$$N = \left(\frac{1.96 * CV}{\alpha} \right)^2 * (1.534)^2 \quad (4.1)$$

Table 4.5. Mean and std dev of the anthropometric measurements in the pilot study
(all measurements in cm except body mass).

No	Anthropometric measurements	$\bar{x}(s)$	No	Anthropometric measurements	$\bar{x}(s)$
1	Body mass (kg)	66.72 (13.37)	35	Sitting elbow rest height (normal)	26.01 (3.26)
2	Stature (erect)	156.23 (6.55)	36	Knee height	47.10 (2.36)
3	Stature (normal)	155.88 (6.43)	37	Popliteal height	37.87 (1.95)
4	Eye height (erect)	145.85 (6.57)	38	Buttock-knee length	55.67 (2.97)
5	Eye height (normal)	145.08 (6.53)	39	Buttock-popliteal length	46.90 (2.43)
6	Acromial (shoulder) height (erect)	131.45 (5.80)	40	Thigh clearance	13.73 (1.54)
7	Acromial (shoulder) height (normal)	130.48 (6.00)	41	Buttock-leg length	94.49 (4.34)
8	Elbow height (normal)	95.52 (5.40)	42	Sitting vertical grip reach	115.65 (5.19)
9	Fingertip height (normal)	58.78 (3.72)	43	Sitting vertical thumb-tip reach	119.27 (5.34)
10	Thumb-tip height (normal)	64.72 (3.77)	44	Sitting vertical fingertip reach	124.49 (5.30)
11	Fist (grip axis) height (normal)	69.24 (4.01)	45	Sitting forward grip reach	65.51 (3.22)
12	Waist height (normal)	89.20 (5.18)	46	Sitting forward thumb-tip reach	69.53 (3.43)
13	Vertical grip reach	185.54 (8.06)	47	Sitting forward fingertip reach	75.14 (3.60)
14	Vertical thumb-tip reach	190.34 (8.11)	48	Head circumference	55.25 (1.67)
15	Vertical fingertip reach	195.52 (8.16)	49	Head length	17.84 (0.81)
16	Forward grip reach	64.56 (3.14)	50	Head breadth	15.01 (0.64)
17	Forward thumb-tip reach	68.98 (3.59)	51	Menton-sellion (face) length	11.72 (0.72)
18	Forward fingertip reach	74.69 (3.73)	52	Bizygomatic (face) breadth	12.75 (0.60)
19	Span	154.87 (7.99)	53	Neck circumference	33.51 (2.18)
20	Elbow span	79.49 (5.26)	54	Chest circumference	97.15 (11.48)
21	Chest (bust) depth	25.94 (3.49)	55	Waist circumference	86.82 (12.97)
22	Chest (bust) breadth	28.04 (3.39)	56	Hip breadth (sitting)	38.12 (3.74)
23	Standing elbow-to-elbow breadth	46.41 (5.55)	57	Sitting elbow-to elbow breadth (normal)	46.11 (5.38)
24	Shoulder-elbow length	34.44 (2.80)	58	Shoulder biacromial breadth	35.21 (2.55)
25	Shoulder-fingertip length	71.71 (4.40)	59	Shoulder bideltoid breadth	41.73 (3.37)
26	Shoulder-grip axis length	61.29 (4.47)	60	Hand length	17.09 (1.04)
27	Foot length	23.21 (1.18)	61	Hand breadth	7.98 (0.47)
28	Foot breadth	9.08 (0.57)	62	Palm length perpendicular	9.54 (0.63)
29	Sitting height(erect)	84.86 (3.89)	63	Index finger length	6.97 (0.59)
30	Sitting height (normal)	84.10 (4.07)	64	Hand Circumference	19.57 (1.16)
31	Sitting eye height (erect)	74.46 (3.92)	65	Wrist circumference	16.20 (1.10)
32	Sitting eye height (normal)	73.67 (3.83)	$\bar{x}$: mean, s: standard deviation		
33	Sitting acromial (shoulder) height (erect)	60.31 (3.49)			
34	Sitting acromial (shoulder) height (normal)	59.17 (3.51)			

where, 1.96 is the critical Z value from a standard normal distribution for a 95% confidence interval; CV is the coefficient of variation; α is the percentage of relative accuracy desired (CI is to be no larger than $\pm$ some percentage of the mean). Moreover, CV is defined as the following:

$$CV = \frac{s}{\bar{x}} * 100 \quad (4.2)$$

where $\bar{x}$ is the sample mean, and s is the sample standard deviation.

Based on the results of the pilot study, mean and standard deviation were calculated for each anthropometric measurement of 100 subjects. Relative accuracy (α) is assumed to be at least 5%. After calculating CV by using mean and standard deviation values in the pilot study, required sample size was calculated for each measurement. The following equations demonstrate the calculation steps of sample size for body weight.

$$CV = \frac{13.37}{66.72} * 100 \cong 20.04 \quad (4.3)$$

$$N = \left(\frac{1.96 * 20.039}{5} \right)^2 * (1.534)^2 \cong 145 \quad (4.4)$$

The N value calculated for body weight was 145. This N value was also the maximum of all N values among 65 measurements. Although 145 subjects were satisfactory to make the study, in order to increase the accuracy of the results, 250 female subjects were measured for the actual study. Calculations for required sample size for each measurement are shown in the appendix B.3.

Moreover, the subjects in the pilot study were measured more than once for each body dimension in order to get used to the measurement procedure and to calibrate the equipment used when required.

4.4.3. Distribution of Subjects

250 female subjects were distributed homogenously in the study in terms of their family origin to estimate the anthropometric characteristics of female population of Turkey. In other words, the study is designed to allocate 250 female subjects almost equally sized samples from 7 regions of Turkey. The subjects were stratified based on their fathers' official provinces. However, in order to have detailed database, the survey also included subjects' birthplace, fathers' and mother's birthplace. The regional distribution of family origins of the subjects is summarized in Table 4.6 and Figure 4.6.

As well as the regional family origin distribution, the study is designed to select equal numbers of each of 5 age-groups (18-29, 30-39, 40-49, 50-59, 79), and each of 2 job-groups (manual and non-manual) as much as possible as shown in Table 4.7, Table 4.8 and Figure 4.7.

Table 4.6. Number of the subjects in terms of region of family origin.

Region	Subjects
Aegean	35
Marmara	34
Black Sea	39
Mediterranean	37
Central Anatolia	34
Eastern Anatolia	38
Southeastern Anatolia	33
Total	250

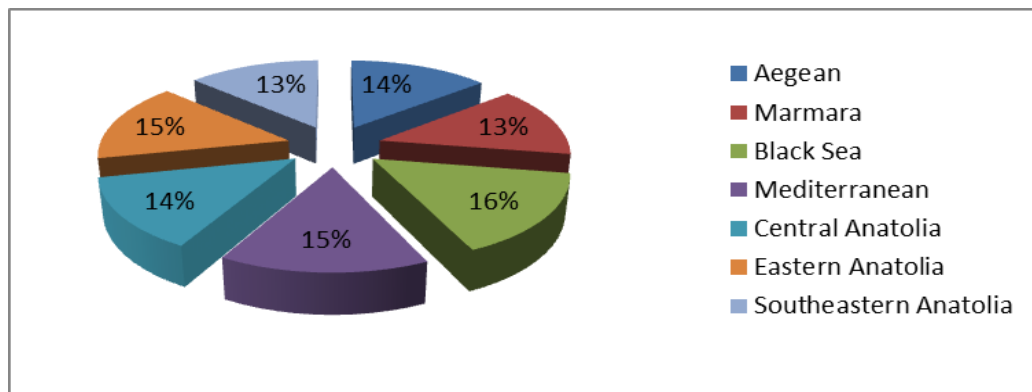


Figure 4.6. Distribution of the subjects in terms of region of family origin

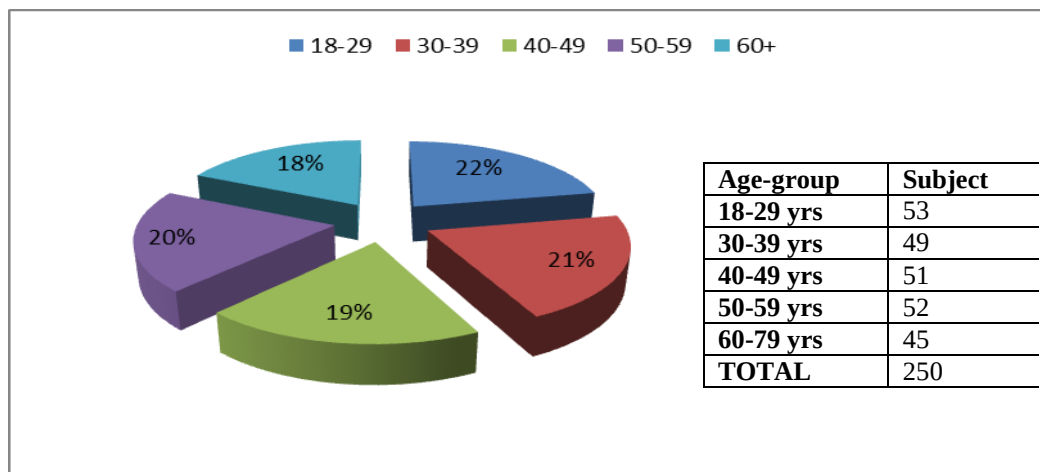


Figure 4.7. Distribution of the subjects in terms of the age groups btw. 18 and 60-79 yrs.

Table 4.7. Number of subjects in terms of occupation and age groups.*

Job-group	Age-group					Total
	18-29 yrs	30-39 yrs	40-49 yrs	50-59 yrs	60-79 yrs	
Non-Manual	33	30	23	17	20	123
Manual	22	22	25	33	25	127

Table 4.8. Distribution of occupations of subjects*

Non-Manual Workers		Manual Workers
Aircraft supervisor (1)	Marketing specialist (1)	Aircraft mechanic (1)
Bank teller (5)	Nurse (7)	Assembler (6)
Biologist (3)	Office clerk (4)	Babysitter (1)
Bookkeeper (3)	Personnel supervisor (1)	Building caretaker (1)

Table 4.8. Distribution of occupations of subjects*. (cont.)

Non-Manual Workers		Manual Workers
Broker (1)	Photographer (1)	Cashier (1)
Business analyst (3)	Procurement manager (1)	Cook (2)
Cafe Manager (2)	Procurement officer (1)	Domestic cleaner (14)
Chemist (3)	Psychiatrist (2)	Dry-cleaner (1)
Computer operator (3)	Sales clerk (1)	Fitness Instructor (1)
Copy writer (2)	Sales representative (4)	Housekeeper (5)
Doctor (3)	Secretary (2)	Housewife (79)
Finance clerk (2)	Software developer (1)	Kitchen assistant (1)
Financial Adviser (1)	Software Engineer (1)	Launderer (1)
Financial Manager (2)	Student (30)	Machine operator (4)
Hairdresser (1)	Supply officer (3)	Manicurist (1)

Human resources assistant (1)	Tax officer (1)	Sales Assistant (1)
IT manager (1)	Teacher (10)	Security guard (1)
Lawyer (1)	Translator (3)	Tailor (2)
Librarian (7)	Writer (1)	Waiter (4)
Managing director (1)		
Manufacturing Manager (1)		
Marketing manager (1)		

* Housewives were accepted as manual workers, and students were accepted as non-manual workers. In addition, retired subjects were evaluated in accordance with the years of working in the past.

Body Mass Index (BMI) is an index of body weight-for-height, which is used to classify underweight, overweight, and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2). The measurements of body weight and stature (normal) are used to calculate Body mass index. Individuals with BMI <18.5 are underweight; those between 18.5 and 25 have normal weight; and those at 25 or greater are overweight. Equation 4.5 shows the formula for calculating Body mass index. The classification method is shown in Table 4.9.

$$BMI = (Weight) (kg) / (Height)^2 (m)^2 \quad (4.5)$$

Table 4.9. BMI classification and number of subjects in terms of their BMI values.

Category	BMIP range	Subjects
Underweight	< 18.5	5
Normal	$18.5 \leq x < 25$	91
Overweight	≥ 25	154
TOTAL		250

At least 65 measurements were recorded for each subject. Since there were 250 subjects in the study, the total number of anthropometric measurement in this study is $65 * 250 = 16250$. Initially, the measurement of each subject had taken about 50 minutes and decreased gradually to about 30 min. over time. Approximately 200 hours were spent in total for taking measurements.

4.5. Measurement Procedure

After each candidate filled a “Brief Medical History Form” in Turkish, subjects who did not have any bodily defects were accepted to participate to the study. English version of the form could be found in Appendix A.1 and Appendix A.2 is the Turkish version. Then, accepted participants signed the “Personal Consent Form” in Turkish (Appendix A.4). English version of this form could be found in and Appendix A.3.

A “Personal Data Form” was filled by the experimenter (Appendix A.5). The form included subject’s information about age, occupation, the city where the subject lives now, family origin, and mother’s and father’s birthplace. The form was divided into two parts and the next part, which included values of body dimensions (e.g. stature, body mass, eye height, sitting popliteal height, hand length) is filled by the investigator after measuring each subject.

In the last step before taking anthropometric measurements of each subject, subjects were asked to read “Instructions” in Turkish (Appendix A.7) in order to be familiar the procedure of the study. Appendix A.6 shows English version of those instructions.

For each anthropometric measurement, the posture of the subject is determined according to the National Health and Nutrition Examination Survey (NHANES, 2007) Nasa Standards (NASA-STD-3000, 1981) and ISO procedures (ISO 7250-1, 1984). All body dimensions were measured in the Boğaziçi University Ergonomics Labaratuary (ErgoLab).

Following steps are taken for the weight measurement:

- (i) The investigator zeroes the scale and the subject wears minimal clothing. Jewelry, watch and other object are removed. Pockets are emptied.
- (ii) Shoes off and person stands on the center of the scale with feet close and arms on the side close to the body. Body weight is distributed evenly on both feet.
- (iii) Person stands still, looking straight ahead, and record the weight in kilograms.

Following steps are taken for standing measurements:

- (i) For stature, shoes off and heels together with toes are pointing out about 60 degree angle and heels are touching on the base of the vertical back board of the stadiometer.
- (ii) For other standing measurements, shoes off and heels together with toes are pointing out about 60 degree angle and heels are touching on the base of the grid board.
- (iii) Body weight is distributed evenly on both feet. Arms and shoulders are on the side in relaxed position.
- (iv) Buttock and shoulder blades are touching on the vertical board.
- (v) Head is in the Frankfurt Plane (Orbitale-Tragion horizontal line in Figure 4.8). So, head is parallel to the floor and perpendicular to the vertical board (Note: for some people all body points may not touch on the board).
- (vi) All head ornaments etc. on top of the head are removed.
- (vii) Person looks straight ahead. For erect position, subject takes a deep breath and holds it and stands as tall as possible (Deep breath forces spine to be more straight). For normal positions, subject is relaxed while breathing normally.
- (viii) For stature, move the sliding bar of the stadiometer so that it is firmly touching the head (with sufficient pressure to compress the hair); and then measurement is taken. Figure 4.9 shows the subject's position for standing height.

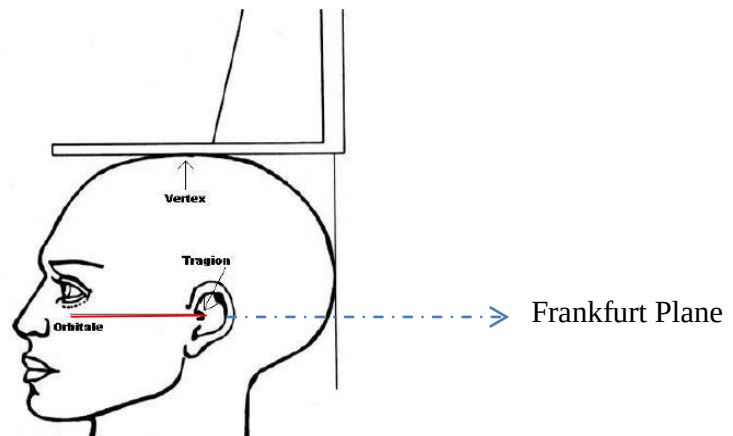


Figure 4.8. Head positioned in the Frankfurt Plane (Adapted from the ISAK Manual, 2001).

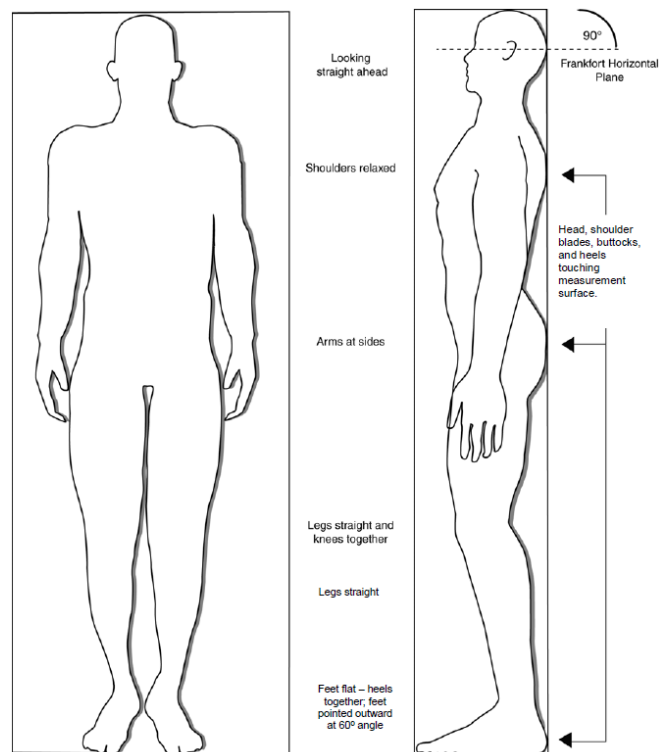


Figure 4.9. The standing posture (NHANES, 2007).

Following steps are taken for sitting measurements:

- (i) Subject sits while torso is making 90 degree angle with upper legs and knee is in 90 degree angle while feet are firmly touching on the floor or board.
- (ii) Buttock and shoulder blades and are touching on the vertical board.
- (iii) Head is in the Frankfurt Plane, so is parallel to the floor and perpendicular to the vertical board (for some people all body points may not touch on the board).
- (iv) All head ornaments etc. on top of the head are removed.
- (v) Person looks straight ahead. For normal positions, subject is relaxed while breathing normally. For erect position, subject takes a deep breath and holds it and stands as tall as possible (Deep breath forces spine to be more straight). The seated posture can be seen in detail in Figure 4.10.

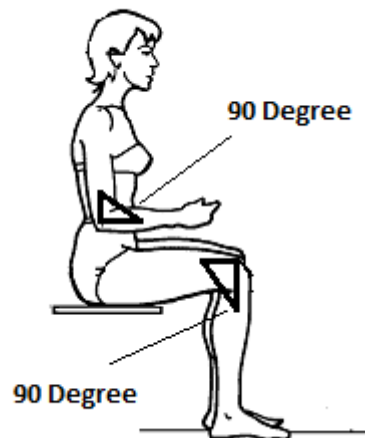


Figure 4.10. The seated posture (NASA-STD-3000 268).

For the measurements related to circumferences, the following steps have to be provided:

- (i) In order to avoid from inaccurate reading, the muscle of the arm should be relaxed. The technician stands to the dominant side of the subject.
- (ii) The measuring tape is held gently on the skin surface.
- (iii) In order to avoid from compressing the skin and the underlying subcutaneous tissue, the two ends of the overlapping tape are pulled together and the measure is recorded (NHANES, 2007).

Measurements such as stature, eye height, shoulder height, elbow height, waist height, hip height, fist-grip axis height and knee height, and all the vertical reach positions including span and elbow span measurements were measured with grid board and stadiometer. The subject stands with shoes-off stood still with his shoulders and hip touching the wall and eyes looking forward for these measurements. For seated measurements, adjustable height seat was used. Breadth and some length dimensions were taken with calipers and antropometers whereas measuring tapes were used for the circumferences.

Upper and lower extremity measurements were taken from the dominant side of the subject; some of them in standing postures, and others in sitting postures. Those positions are illustrated in Figure 4.11, Figure 4.12, Figure 4.13 and Figure 4.14.



Figure 4.11. Position for the vertical dimensions in stand. obtained by stadiometer.

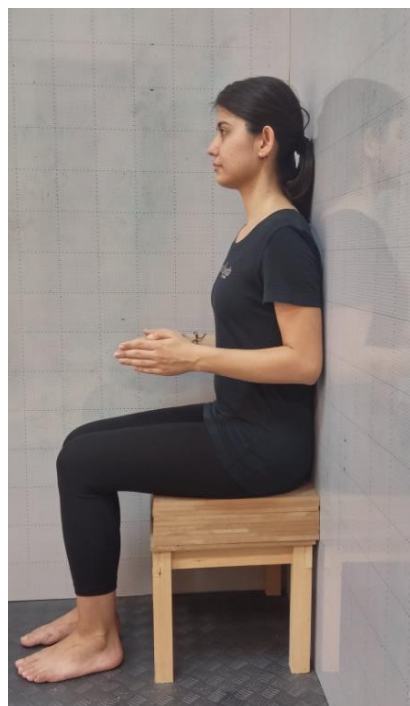


Figure 4.12. Position for the vertical dimensions in sitting obtained by adjustable height seat.



Figure 4.13. Position for the forward dimensions in standing obtained by grid board and handle diameter.



Figure 4.14. Position for the vertical dimensions in standing obtained by grid board.

Small anthropometers and calipers were used for foot and hand measurements.

Figure 4.15 shows measurement of foot length in this study and Figure 4.16 is for hand length measurement.



Figure 4.15. Measurement of foot breadth obtained by caliper.



Figure 4.16. Measurement of hand length obtained by caliper.

Measuring tapes were used for the circumference measurements. Figure 4.17 demonstrates the measurement of neck circumference. Head, hand, wrist, neck, chest and waist circumferences were also taken with the measuring tape.



Figure 4.17. Measurement of neck circumference obtained by measuring tape.

The measuring process was speeded up by applying the following:

- (i) Subjects firstly were measured in standing positions in order to minimize movements. Then seated measurements were taken. Lastly, circumference measurements were obtained.
- (ii) The experimenter performed each measurement by dominant side which is the right hand.

4.6. Statistical Methods

4.6.1. Statistical Variables

Table 4.10. Independent factors to be investigated.

Independent factors	Level
Age-group	(i) 18-29 years (ii) 30-39 years (iii) 40-49 years (iv) 50-59 years (v) 60-79 years
Job-group	(i) Non-manual worker (ii) Manual worker
BMI-group	(i) Underweight (BMI of the subject is less than 18.5)* (ii) Normal (BMI of the subject is between 18.5 to 25) (iii) Overweight (BMI of the subject is above 25)

* Underweight people are excluded for statistical analysis since there was only five underweight subjects.

One of the objectives of this study is to investigate the effects of age-group, job-group and BMI-group on some of the measured dimensions (response variables). These independent factors of the study are shown in Table 4.10.

4.6.2. Statistical Analysis

Minitab version 17.0. was used for making statistical analysis. P-values $0.05 \leq p \leq 0.1$ were accepted as marginal and p-values ≤ 0.05 were accepted as significant.

4.6.2.1. Descriptive Statistics for Age-Groups, Job-Groups and BMI-Groups. After all measurements were taken, descriptive statistics such as mean, standard deviation, range and percentiles (5th, 50th and 95th) were calculated.

4.6.2.2. Inferential Statistics. Inferential statistics used in this study are as following:

- (i) Correlation analysis: In order to investigate the strength of linear relationship between variables, Pearson's correlation coefficient was used.

- (ii) Analysis of Variance: Three-way analysis of variance (ANOVA) was utilized for testing the equality of means of the responses for age-group, job group, and BMI-group. Following three assumptions were satisfied when using ANOVA:
- (iii) The error terms (residuals) of the model must distribute normally, zero being the center of the distribution ($\sim$ NID Normal (0, σ^2)) (normality assumption).
 - Error terms must be uncorrelated (correlation of each value and the value before it) and correlation between error terms and independent variables (autocorrelation between residuals).
 - The variances of response variables for each treatment must not be different from each other (homogeneity assumption).

Anderson-Darling normality test and normal probability plot of residuals were used to decide if normality assumption of residuals of anthropometric data was satisfied. For all independent variables, it was deduced that they approximately follow normal distribution. Next, Pearson's correlation coefficients between residuals for each anthropometric measurement were calculated in order to check autocorrelations between residuals, and results showed that they were independent to each other. To check homogeneity assumption, Bartlett's test was applied to test that the sample variances in each treatment were not statistically different. Plot of residuals versus the fitted response were also investigated to support the results. Three assumptions of ANOVA were satisfied; therefore it was convenient to investigate if any of the independent variables had an effect on each anthropometric measurement. The area of intent was testing the equality of the means of response variables at the combination of 5 age groups, 2 job groups and 2 BMI groups. In total there were $2 \times 2 \times 5 = 20$ combinations.

The hypothesis in ANOVA state that the means of the groups are equal as given in Equation 4.6 (Montgomery, 2005):

$$\begin{aligned} H_0 : \mu_1 &= \mu_2 = \mu_3 \dots \dots \dots = \mu_{20} \\ H_1 : \mu_i &\neq \mu_j \end{aligned} \quad (4.6)$$

for at least one pair ($i \neq j$) and in this study. If the null hypothesis is true, it means that these 3 groups have equal means.

The mathematical model which describes the relationship between response and treatment for three-way ANOVA is given as following. Since there was no significant interaction effect, the effect is excluded from the model (Montgomery, 2005):

$$y_{ijk} = \mu + \alpha_i + \chi_j + \delta_k + \varepsilon_{ijk} \quad (4.7)$$

where,

y_{ijk} : ijk^{th} response (each body dimension)

μ : overall response mean

α_i : effect of i^{th} level for age-group factor (i: 1,2,3,4,5)

χ_j : effect of j^{th} level for job-group factor (j: 1, 2)

δ_k : effect of k^{th} level for BMI-group factor (k:1,2; underweight group was excluded since there were only 5 subjects in this group)

ε_{ijk} : NID (0, σ^2) random error component

- (iii) Post-hoc analysis: After ANOVA, a multiple comparison test was performed. Tukey's test was used for post-hoc analysis. This is because it tests all pairwise differences, it is simple to compute, and reduces the probability of making a Type I error. It is also robust with respect to unequal group sample sizes (McHugh, 2011). Moreover, because of computational simplicity and its statistical features, Tukey's test is recommended (Jaccard *et. al*, 1984). The hypothesis of this test is as the following (Montgomery, 2005):

$$\begin{aligned} H_0: \mu_i &= \mu_j \\ H_1: \mu_i &\neq \mu_j \end{aligned} \quad (4.8)$$

where i and j are treatment levels ($i \neq j$). Tukey's procedure utilizes the distribution of the studentized range statistic which is calculated as (Montgomery, 2005):

$$q = \frac{\bar{y}_{max} - \bar{y}_{min}}{\sqrt{MSE/n}} \quad (4.9)$$

where $\bar{y}_{max}$ and $\bar{y}_{min}$ are the greatest and the smallest sample means, MSE is mean squares due to error and n is the sample size. Using q value, T value of Tukey's test for unequal sample sizes can be calculated as (Montgomery, 2005)

$$T_{\alpha} = \frac{q_{\alpha}(p, f)}{\sqrt{2}} \sqrt{MSE \left(\frac{1}{n_i} + \frac{1}{n_j} \right)} \quad (4.10)$$

where $q_{\alpha}(p, f)$ is the upper α percentage points of studentized range statistics q , p is the number of groups will be compared, f is the number of degrees of freedom associated with the MSE , n_i and n_j are the sample sizes of the groups. In addition, a set of $100(1 - \alpha)$ confidence intervals for all pairs of means can be constructed as follows (Montgomery, 2005):

$$\begin{aligned} \bar{y}_i - \bar{y}_j - \frac{q_{\alpha}(p, f)}{\sqrt{2}} \sqrt{MSE \left(\frac{1}{n_i} + \frac{1}{n_j} \right)} &\leq \mu_i - \mu_j \\ &\leq \bar{y}_i - \bar{y}_j + \frac{q_{\alpha}(p, f)}{\sqrt{2}} \sqrt{MSE \left(\frac{1}{n_i} + \frac{1}{n_j} \right)} \end{aligned} \quad (4.11)$$

where $\bar{y}_i$ and $\bar{y}_j$ are the sample means of i^{th} and j^{th} groups and μ_i and μ_j are the population means of i^{th} and j^{th} groups ($i \neq j$).

- (iv) Paired t- tests: Since it can be more powerful than a two sample t-test, for erect and normal positions of some anthropometric measurements, paired t-test was used for comparing sample means. The reason behind this is that a paired t-test is not subject to the additional variation arising from the independence of the observations. Moreover, a paired t-test does not need both samples to have equal variance. Therefore, in order to gain statistical power for analyzing differences between two treatments given to the same subject, paired t-test is more useful (Minitab Inc., 2008). The hypotheses of paired t-test are (Montgomery, 2005):

$$\begin{aligned} H_0: \mu_d &= 0 \\ H_1: \mu_d &\neq 0 \end{aligned} \quad (4.12)$$

where μ_d is the difference of the means between two groups. The test statistic for the hypothesis is stated as the following

$$t_0 = \frac{\bar{d}}{s_d/\sqrt{n}} \quad (4.13)$$

where the sample mean of the differences is calculated as the following;

$$\bar{d} = \frac{1}{n} \sum_{j=1}^n d_j \quad (4.14)$$

The sample standard deviation of the differences is calculated as the following;

$$s_d = \sqrt{\frac{\sum_{j=1}^n (d_j - \bar{d})^2}{n-1}} \quad (4.15)$$

where n is the sample size, and d_j is the j^{th} paired difference (Montgomery, 2005).

(v) The hypothesis of a general t-test is stated as (Montgomery, 2005):

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2 \quad (4.16)$$

where $\bar{y}_1$ and $\bar{y}_2$ are means of group 1 and 2. The test statistic is calculated as:

$$t_0 = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (4.17)$$

where $\bar{y}_1 - \bar{y}_2$ are the sample means, n_1 and n_2 are the sample sizes, s_1^2 and s_2^2 are the sample variances. The distribution of t_0 is well approximated by t if we use;

$$v = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} \right)^2}{\frac{s_1^2}{\frac{n_1}{n_1-1}} + \frac{s_2^2}{\frac{n_2}{n_2-1}}} \quad (4.18)$$

(vi) Regression Analysis: In order to make regression analysis and develop prediction equations for anthropometric measurements, regression models were firstly obtained by four variables including stature, body mass, age and job-group. Then by using stepwise regression approach, regression models with independent variables were found which maximize R_{adj}^2 values considering C_p as well.

The relationship between independent variables and each one of anthropometric measurements was also a point of interest in the study. For this reason, multiple linear regression models were used for statistical analysis. The general form of the multiple linear regression equation is as the following (Montgomery, 2005):

$$y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \cdots + \beta_k\chi_k + \varepsilon \quad (4.19)$$

where

β_0 : Constant

$\beta_1, \beta_2, \beta_3, \dots, \beta_k$: Regression coefficients for independent variables,

$\chi_1, \chi_2, \chi_3, \chi_4, \dots, \chi_k$: Independent variables,

ε : Error term ($\varepsilon \sim NID(0, \sigma^2)$).

Before starting the regression analysis, the following assumptions are checked (Montgomery, 2005):

- Linearity: There should be a linear relationship between the dependent and independent variables. Minor deviations from this assumption do not affect multiple regression procedures.
- Normality: The residuals of the independent variables should distribute normally. Normal probability plots of residuals can be used to check this assumption
- Multicollinearity: Redundant variables in the regression cause multicollinearity. In order to check this assumption, variance inflation factor (VIF) is used. VIF value is desired to be smaller than 5.
- Homogeneity of variances: The variances within groups must be equal. To check this assumption, Bartlett's test can be used.
- Autocorrelation: Since correlation affects the estimation of coefficients for the regression, there must not be correlation between the errors. To verify this assumption, Durbin-Watson statistic is used. The statistics is desired to be between values 1.5 and 2.5.

After determining the regression models, a test for significance of regression was performed to check the goodness of model (Montgomery, 2005).

The model utility test is performed in order to check the significance of the model. The hypothesis of this test is:

$$\begin{aligned}
H_0: \beta_1 &= \beta_2 = \beta_3 = \dots = \beta_n \\
H_1: \beta_j &\neq 0 \text{ for at least } j \text{ (} j = 1, 2, \dots, n \text{)}
\end{aligned} \tag{4.20}$$

If H_0 hypothesis above is rejected, at least one of the regressor variables contributes significantly to the model. An ANOVA table, which considers the total sum of squares, sum of squares due to regression model and sum of squares due to residual, is used for checking the significance of regression model. If the p-value is less than α significance level, the null hypothesis H_0 is rejected, which implies that at least one of the regressor variables contributes significantly to the model (Montgomery, 2005).

In order to see the goodness of fit of the regression model, R_{adj}^2 statistics were examined. R^2 is the square of the correlation between the actual and the predicted values of the dependent variable. R_{adj}^2 is used incorporates the model's degrees of freedom and could be interpreted as the proportion of total variance that is explained by the model. R_{adj}^2 statistic only increase as predictors are added if the increase in model fit is improved. (Grace Martin, 2012).

For each age group and job group, percentile calculations for each anthropometric measurement were also made for adult female subjects.

5. RESULTS

5.1. Descriptive Statistics

5.1.1. Mean, Standard Deviation, Minimum and Maximum Statistics of Measurements

The means, standard deviations, minimum and maximum values of each anthropometric measurement stratified by age-group, job-group and BMI-group were calculated. Table 5.1 represents anthropometric measurements stratified by age-group; Table 5.2 shows anthropometric measurements stratified by job-group and Table 5.3 indicates anthropometric measurements stratified by BMI-group (Here, underweight people were excluded in calculations since there were only 5 subjects underweight. Since the number is too low, it is not enough to make accurate conclusions about the results).

According the results of Table 5.1, the people older than 60 years-old are heavier and shorter than other age-groups while those at their 20s are the tallest. Table 5.2 indicated that manual workers are heavier and shorter than non-manual workers. The measurements given in Table 5.3 show that overweight women are heavier by almost 17 kg than normal weight women. In this statistical analysis, underweight people were excluded since there were only 5 people in this category.

Table 5.1. Anthropometric measurements stratified by age-group (all in cm except body mass).

NO	Measurement	Overall (n=250)		18-29 years (n=55)		30-39 years (n=52)		40-49 years (n=48)		50-59 years (n=50)		60-79 years (n=45)	
		$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max
1	Body mass (kg)	66.50 (12.99)	42.0 -120.0	59.19 (11.22)	46.0 -118.0	65.96 (13.88)	48.0 -120.0	64.85 (10.88)	42.0 -98.0	71.60 (11.97)	50.0 -102.0	72.16 (12.81)	49.0 -105.0
2	Stature (e)	157.02 (6.62)	141.8 -176.1	160.67 (6.82)	144.0 -174.9	158.55 (4.99)	147.8 -170.6	154.81 (6.17)	141.8 -172.8	156.58 (6.14)	145.2 -176.1	153.63 (6.67)	142.6 -169.4
3	Stature (n)	156.65 (6.54)	141.6 -175.7	160.26 (6.70)	143.8 -174.0	158.15 (4.99)	147.5 -170.2	154.43 (6.07)	141.6 -171.8	156.26 (6.03)	144.5 -175.7	153.32 (6.63)	142.5 -169.1
4	Eye ht (e)	146.51 (6.71)	131.6 -166.4	150.32 (7.12)	133.6 -166.4	147.76 (5.12)	138.1 -160.6	144.25 (6.13)	132.8 -162.6	146.19 (6.21)	135.7 -164.9	143.16 (6.61)	131.6 -157.5
5	Eye ht (n)	145.73 (6.65)	131.0 -165.0	149.41 (6.98)	132.6 -165.0	146.89 (5.18)	136.6 -159.5	143.58 (6.12)	132.1 -161.7	145.52 (6.21)	135.0 -164.1	142.45 (6.59)	131.0 -157.1
6	Acr. (shld) ht (e)	132.00 (5.88)	118.0 -150.0	134.70 (5.97)	120.0 -150.0	132.74 (4.85)	123.0 -143.4	129.74 (5.60)	119.5 -146.1	132.17 (5.44)	119.5 -148.4	130.05 (6.40)	118.0 -144.5
7	Acr. (shld) ht (n)	131.15 (6.13)	117.1 -150.8	133.65 (5.88)	118.5 -146.3	131.64 (4.91)	122.4 -142.3	128.76 (5.56)	119.1 -145.5	131.40 (5.88)	118.8 -148.0	129.78 (7.48)	117.1 -150.8
8	Elbow ht (n)	96.28 (5.03)	69.2 -110.6	97.98 (5.84)	69.2 -109.2	97.50 (4.03)	89.5 -108.5	94.81 (5.23)	76.5 -105.9	96.25 (4.46)	86.4 -110.6	94.36 (4.69)	86.8 -103.9
9	Fngtip ht (n)	59.36 (3.91)	48.6 -75.0	61.63 (4.20)	53.6 -75.0	60.06 (3.21)	53.5 -70.9	58.10 (3.50)	48.6 -64.7	59.06 (3.37)	53.0 -71.9	57.47 (3.92)	50.6 -66.8
10	Th-tip ht (n)	65.19 (3.86)	55.7 -78.9	67.19 (4.03)	59.1 -78.9	65.94 (3.33)	58.0 -78.0	64.19 (3.24)	55.7 -72.0	64.93 (3.49)	58.8 -77.4	63.23 (4.02)	56.5 -72.6
11	Knuckle ht (n)	69.80 (4.12)	54.7 -83.5	72.03 (3.95)	64.5 -83.4	70.23 (3.74)	61.0 -83.5	68.81 (3.74)	60.4 -77.0	69.62 (3.62)	62.2 -83.0	67.86 (4.51)	54.7 -77.2
12	Waist ht (n)	89.52 (5.25)	72.4 -102.4	91.27 (5.17)	78.3 -101.4	91.13 (4.52)	75.9 -98.8	88.89 (4.90)	79.3 -99.9	89.24 (5.15)	80.1 -102.4	86.50 (5.29)	72.4 -97.6
13	Vertical grip rch	185.92 (8.56)	150.6 -208.1	189.26 (8.08)	168.0 -205.4	187.65 (6.96)	171.9 -206.9	183.55 (7.63)	169.0 -201.1	186.85 (7.04)	169.4 -208.1	181.32 (10.59)	150.6 -204.0
14	Vertical th-tip rch	190.68 (8.65)	155.0 -213.5	194.10 (8.37)	171.5 -210.6	192.36 (6.80)	176.0 -211.5	188.51 (8.03)	172.2 -208.2	191.52 (7.15)	173.7 -213.5	185.92 (10.50)	155.0 -207.6
15	Vertical fngtip rch	195.93 (8.77)	160.2 -219.2	199.84 (8.53)	177.0 -217.1	197.55 (6.80)	181.2 -217.2	193.78 (8.13)	177.4 -214.0	196.56 (7.16)	179.4 -219.2	190.87 (10.49)	160.2 -212.7
16	Forward grip rch	64.52 (3.11)	56.6 -76.1	65.01 (2.79)	58.7 -73.2	63.97 (2.72)	57.3 -70.3	63.85 (2.75)	59.2 -70.0	65.03 (3.03)	56.6 -71.2	64.67 (4.17)	58.9 -76.1
17	Forward th-tip rch	68.99 (3.55)	61.0 -80.5	69.81 (3.36)	62.9 -78.9	68.38 (3.25)	61.0 -77.7	68.41 (3.55)	63.0 -80.5	69.43 (3.24)	61.1 -76.0	68.82 (4.28)	63.0 -80.3
18	Forward fngtip rch	74.81 (3.76)	65.8 -86.4	75.94 (3.99)	67.5 -86.4	74.36 (3.46)	65.8 -84.6	73.95 (3.24)	68.4 -83.2	75.27 (3.38)	66.8 -82.1	74.38 (4.56)	67.4 -85.9
19	Span	155.46 (7.29)	131.7 -171.6	157.63 (6.52)	135.5 -170.8	156.69 (6.79)	131.7 -168.1	154.22 (6.73)	136.7 -171.6	155.82 (7.03)	132.1 -169.8	152.32 (8.32)	134.7 -166.8
20	Elbow span	79.73 (5.56)	61.8 -91.6	81.65 (4.90)	63.2 -91.6	80.83 (5.11)	62.8 -89.2	78.08 (6.44)	61.8 -90.9	80.30 (4.84)	71.0 -91.0	77.25 (5.50)	64.5 -88.5
21	Chest (bust) depth	26.02 (3.52)	15.4 -36.1	23.68 (2.66)	15.4 -32.0	25.06 (3.37)	19.1 -36.0	25.79 (2.89)	20.8 -36.1	27.90 (3.10)	21.4 -35.6	28.16 (3.24)	20.5 -32.8
22	Chest (bust) brt	28.01 (3.28)	20.1 -37.2	25.73 (2.50)	20.1 -33.7	27.15 (2.70)	22.5 -34.5	27.88 (2.65)	21.1 -36.9	29.58 (3.15)	23.0 -37.2	30.18 (3.18)	21.8 -35.1
23	Stand. e-to-e brt	46.00 (5.59)	29.3 -62.1	41.65 (4.50)	29.3 -57.0	44.78 (4.94)	34.8 -56.7	46.36 (4.91)	32.3 -62.1	47.93 (4.85)	34.7 -56.6	50.21 (4.38)	40.1 -57.6
24	Shld-elbow lgt	34.24 (2.49)	28.4 -47.2	34.69 (2.48)	28.4 -43.8	33.88 (1.96)	30.3 -38.8	33.18 (1.90)	28.6 -37.4	34.94 (2.82)	30.1 -47.2	34.46 (2.80)	28.6 -41.0
25	Shld-fngtip lgt	71.72 (3.91)	61.5 -89.1	71.83 (3.25)	61.5 -81.0	71.45 (3.39)	61.6 -80.1	70.65 (3.73)	61.5 -80.8	72.51 (4.79)	63.8 -89.1	72.13 (4.10)	64.1 -82.4
26	Shld-fist lgt	61.47 (4.22)	50.5 -83.3	61.91 (3.77)	50.5 -70.5	61.31 (3.76)	54.2 -75.1	59.94 (3.61)	51.6 -68.5	61.98 (3.99)	55.0 -75.0	62.16 (5.61)	53.4 -83.3
27	Foot lgt	23.28 (1.19)	19.9 -26.9	23.61 (1.06)	21.4 -26.9	23.39 (1.16)	20.8 -25.9	23.17 (1.28)	19.9 -26.2	23.37 (.87)	20.9 -25.3	22.78 (1.34)	20.2 -26.8
28	Foot brt	9.06 (.63)	7.1 -11.7	8.95 (.58)	7.8 -10.8	8.97 (.62)	7.1 -10.9	9.18 (.68)	8.0 -11.7	9.21 (.58)	7.5 -10.6	9.02 (.57)	8.0 -10.2
29	Sit. ht(e)	85.47 (3.97)	74.0 -94.5	87.05 (4.05)	78.7 -94.5	86.90 (3.82)	77.7 -94.5	84.74 (3.65)	76.5 -93.7	84.80 (3.32)	79.6 -91.7	83.42 (3.89)	74.0 -90.0
30	Sit. ht (n)	84.68 (4.04)	73.6 -94.4	86.19 (4.10)	77.9 -94.0	86.06 (3.90)	76.5 -93.6	84.10 (3.97)	75.2 -94.4	83.98 (3.34)	78.8 -91.0	82.66 (3.92)	73.6 -89.3
31	Sit. eye ht (e)	74.94 (3.97)	63.9 -85.1	76.48 (4.50)	64.4 -85.1	76.13 (3.88)	65.3 -84.8	74.15 (3.44)	66.6 -83.5	74.14 (3.18)	69.1 -82.0	73.41 (3.90)	63.9 -80.1
32	Sit. eye ht (n)	74.14 (3.91)	63.5 -83.6	75.65 (4.43)	63.6 -83.5	75.34 (3.82)	64.4 -83.6	73.28 (3.39)	65.8 -82.9	73.36 (3.16)	68.5 -80.9	72.69 (3.83)	63.5 -79.2
33	Sit. acr. (shld) ht (e)	60.61 (3.52)	49.5 -70.8	61.17 (3.50)	54.1 -69.0	61.04 (3.84)	52.2 -69.5	60.42 (3.64)	52.9 -70.8	60.54 (3.00)	49.5 -65.6	59.68 (3.65)	49.6 -67.9
34	Sit. acr. (shld) ht (n)	59.53 (3.51)	49.0 -69.7	60.01 (3.55)	53.0 -68.5	59.93 (3.79)	50.4 -67.7	59.35 (3.62)	52.5 -69.7	59.40 (3.10)	49.0 -64.7	58.81 (3.56)	49.0 -66.3
35	Sit. elbow rest ht (n)	25.86 (3.22)	16.3 -35.5	26.12 (3.02)	21.0 -34.5	26.36 (3.45)	18.5 -35.5	26.20 (3.63)	18.8 -34.1	25.50 (2.41)	20.5 -31.7	25.00 (3.54)	16.3 -31.3
36	Knee ht	47.24 (2.51)	40.9 -53.7	48.19 (2.36)	42.0 -52.8	47.39 (2.23)	42.2 -51.5	46.60 (2.55)	40.9 -53.5	47.40 (2.28)	43.3 -53.0	46.43 (2.79)	42.2 -53.7
37	Popliteal ht	38.02 (1.98)	34.0 -43.6	39.24 (1.86)	34.0 -43.3	38.02 (1.87)	34.5 -42.2	37.60 (1.59)	34.2 -42.6	37.91 (2.14)	34.2 -43.6	37.11 (1.72)	34.3 -41.2
38	Buttock-knee lgt	55.43 (3.21)	43.2 -63.4	55.67 (2.76)	50.4 -63.4	55.87 (2.46)	49.8 -62.4	54.42 (3.34)	43.2 -60.0	55.82 (3.24)	48.3 -63.1	55.26 (3.97)	44.3 -61.6
39	Buttock-popliteal lgt	46.57 (2.56)	40.5 -55.5	45.87 (2.30)	40.6 -51.2	46.54 (2.19)	40.5 -52.5	45.81 (2.51)	41.0 -52.2	47.20 (2.33)	41.0 -54.6	47.55 (3.08)	41.6 -55.5
40	Thigh clearance	13.65 (1.53)	9.7 -19.7	13.02 (1.32)	10.2 -15.6	14.15 (1.72)	9.7 -19.7	13.61 (1.39)	11.1 -17.2	13.84 (1.39)	10.8 -16.6	13.68 (1.61)	10.5 -19.1
41	Buttock-Leg Lgt	94.45 (4.72)	81.7 -112.4	96.24 (5.11)	81.7 -109.1	94.47 (3.42)	88.1 -101.9	92.81 (4.66)	83.8 -104.5	94.96 (4.25)	85.5 -112.4	93.40 (5.56)	82.1 -104.6

Table 5.1. Anthropometric measurements stratified by age-group (cont.).

NO	Measurement	Overall (n=250)		18-29 years (n=55)		30-39 years (n=52)		40-49 years (n=48)		50-59 years (n=50)		60-79 years (n=45)	
		$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max
42	Sit.vertical grip rch	115.93 (5.12)	102.5 -128.7	117.20 (4.85)	104.0 -127.8	116.51 (4.63)	105.5 -126.7	114.76 (4.95)	105.1 -128.7	116.51 (5.24)	107.1 -128.5	114.32 (5.63)	102.5 -127.2
43	Sit.vertical th-tip rch	119.90 (5.29)	104.0 -133.0	121.54 (4.90)	107.6 -131.3	120.64 (4.82)	109.3 -130.9	118.71 (5.13)	109.5 -133.0	120.49 (5.31)	111.5 -132.2	117.68 (5.72)	104.0 -131.1
44	Sit.vertical fngtip rch	125.16 (5.25)	109.3 -137.2	127.06 (5.15)	111.1 -137.2	126.00 (4.78)	114.5 -136.1	123.73 (4.85)	114.1 -133.6	125.59 (5.02)	115.4 -136.6	122.94 (5.66)	109.3 -136.0
45	Sit.forward grip rch	65.46 (3.38)	57.1 -73.6	65.67 (3.39)	57.1 -73.3	65.05 (3.02)	57.8 -73.6	65.19 (3.76)	58.6 -73.2	65.53 (2.63)	60.4 -71.2	65.88 (4.16)	60.4 -73.6
46	Sit.forward th-tip rch	69.60 (3.59)	61.6 -78.9	69.97 (3.64)	61.6 -78.6	69.24 (3.12)	61.9 -76.0	69.15 (4.11)	62.1 -78.2	69.82 (2.91)	64.7 -76.0	69.76 (4.25)	64.1 -78.9
48	Head circumf	55.40 (1.69)	51.5 -60.5	55.20 (1.58)	52.2 -59.7	55.53 (1.70)	51.5 -59.1	55.30 (1.77)	51.9 -59.0	55.51 (1.77)	51.8 -60.5	55.46 (1.56)	52.2 -58.9
49	Head lgt	17.89 (.85)	14.5 -20.7	17.94 (.91)	14.5 -20.2	17.90 (.77)	15.7 -19.7	17.93 (.84)	16.0 -20.4	17.74 (.78)	16.1 -19.6	17.94 (.84)	16.1 -20.7
50	Head brt	15.04 (.73)	12.4 -18.2	15.11 (.84)	13.3 -18.2	15.00 (.60)	13.0 -16.3	14.97 (.67)	13.9 -17.6	15.03 (.64)	12.4 -16.0	15.09 (.73)	13.0 -17.2
51	Ment-sellion (face) lgt	11.84 (.84)	9.3 -15.5	11.72 (.86)	9.8 -15.0	11.89 (.71)	9.7 -13.9	11.89 (.78)	10.4 -14.0	11.75 (.88)	9.3 -13.4	11.99 (.80)	10.4 -15.5
52	Bizygomatic (face) brt	12.73 (.68)	10.8 -15.3	12.47 (.71)	11.1 -14.5	12.78 (.61)	10.8 -14.5	12.57 (.59)	11.1 -13.7	12.88 (.61)	11.8 -15.3	13.01 (.68)	11.7 -14.5
53	Neck circumf	33.49 (2.23)	28.6 -40.6	32.16 (2.06)	28.6 -39.3	33.16 (2.14)	29.4 -40.6	33.38 (2.05)	29.6 -39.5	34.26 (1.71)	30.4 -39.4	34.74 (2.11)	31.2 -39.2
54	Chest circumf	97.32 (11.20)	70.1 -127.2	89.41 (8.57)	70.1 -118.6	94.08 (9.14)	79.3 -122.6	96.70 (8.62)	76.6 -118.0	102.94 (10.93)	83.4 -127.2	105.11 (10.22)	82.0 -123.1
55	Waist circumf	85.97 (13.17)	60.2 -123.2	75.60 (8.93)	60.2 -107.7	82.21 (10.94)	62.9 -111.6	84.04 (9.15)	62.9 -112.4	92.44 (11.71)	70.5 -117.6	97.87 (11.45)	67.3 -123.2
56	Hip brt (sit.)	37.96 (3.51)	29.6 -51.1	36.13 (2.85)	29.6 -46.1	37.80 (3.82)	29.7 -49.9	37.76 (3.02)	29.7 -43.8	39.27 (3.58)	33.2 -51.1	39.16 (3.07)	32.4 -47.4
57	Sit. e-to-e brt (n)	45.75 (5.31)	32.2 -59.0	41.87 (3.65)	32.2 -56.0	44.72 (5.23)	33.9 -58.3	45.71 (4.21)	34.0 -57.2	47.50 (4.72)	38.0 -59.0	49.80 (4.84)	40.2 -58.6
58	Shld biacr. brt	35.11 (2.59)	27.7 -42.1	35.13 (2.08)	29.7 -39.6	35.23 (2.95)	29.2 -40.1	35.38 (2.49)	30.6 -41.9	35.05 (2.79)	29.3 -41.2	34.72 (2.66)	27.7 -42.1
59	Shld bideltoid brt	41.59 (3.36)	31.2 -53.3	39.80 (2.52)	35.6 -48.5	41.58 (3.32)	34.8 -53.3	41.66 (3.13)	33.1 -50.9	42.49 (3.37)	34.5 -50.0	42.72 (3.58)	31.2 -50.7
60	Hand lgt	17.17 (.97)	14.9 -20.8	17.19 (1.20)	14.9 -20.8	17.29 (.81)	15.3 -19.5	17.07 (.84)	14.9 -19.2	17.30 (.99)	15.2 -19.7	16.94 (.93)	15.1 -18.8
61	Hand brt	7.98 (.51)	6.0 -9.8	7.72 (.46)	6.4 -9.6	7.90 (.48)	6.0 -8.9	8.00 (.43)	7.2 -9.8	8.20 (.48)	7.3 -9.8	8.13 (.45)	7.2 -9.1
62	Palm lgt perp	9.57 (.63)	6.8 -11.6	9.49 (.60)	7.8 -11.2	9.69 (.57)	7.8 -11.2	9.45 (.60)	8.1 -11.0	9.65 (.64)	7.3 -10.9	9.56 (.73)	6.8 -11.6
63	Index finger lgt	6.97 (.52)	5.6 -9.0	7.12 (.55)	6.2 -8.9	6.94 (.47)	6.1 -8.7	6.97 (.54)	6.1 -9.0	7.06 (.51)	6.2 -8.9	6.74 (.41)	5.6 -7.6
64	Hand circumf	19.53 (1.17)	16.5 -22.6	18.84 (1.03)	16.5 -22.4	19.35 (1.14)	17.0 -21.7	19.63 (1.05)	17.9 -22.2	20.02 (.97)	17.5 -22.6	19.92 (1.18)	16.6 -22.6
65	Wrist circumf	16.19 (1.22)	13.3 -19.4	15.37 (.93)	13.6 -18.0	16.06 (1.36)	13.3 -19.4	16.28 (.94)	14.3 -18.5	16.58 (1.13)	13.3 -19.4	16.83 (1.09)	14.8 -19.4

Table 5.2. Anthropometric measurements stratified by job-group (all in cm except body mass).

No	Measurement	Non-manual workers (n=127)		Manual workers (n=123)	
		$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max
1	Body mass (kg)	63.75 (12.31)	42.0 -118.0	68.70 (12.77)	45.0 -120.0
2	Stature (e)	157.92 (6.72)	141.8 -176.1	155.72 (6.69)	141.8 -172.8
3	Stature (n)	157.54 (6.63)	141.6 -175.7	155.38 (6.60)	141.6 -171.8
4	Eye ht (e)	147.32 (6.84)	132.0 -166.4	145.26 (6.74)	131.6 -163.8
5	Eye ht (n)	146.52 (6.77)	131.1 -165.0	144.50 (6.70)	131.0 -162.2
6	Acr. (shld) ht (e)	132.38 (5.84)	118.0 -150.0	131.16 (6.01)	119.0 -146.1
7	Acr. (shld) ht (n)	131.24 (5.87)	117.1 -148.0	130.52 (6.55)	118.5 -150.8
8	Elbow ht (n)	96.51 (5.35)	69.2 -110.6	95.64 (5.08)	76.5 -109.2
9	Fngtip ht (n)	59.81 (4.17)	48.6 -75.0	58.71 (3.65)	48.6 -68.2
10	Th-tip ht (n)	65.55 (4.00)	55.7 -78.9	64.72 (3.73)	55.7 -74.8
11	Knuckle ht (n)	70.05 (4.43)	54.7 -83.5	69.29 (3.86)	60.4 -77.6
12	Waist ht (n)	90.36 (5.06)	72.4 -102.1	88.45 (5.40)	75.9 -102.4
13	Vertical grip rch	186.86 (8.08)	159.1 -208.1	184.50 (9.11)	150.6 -205.4
14	Vertical th-tip rch	191.63 (8.18)	165.8 -213.5	189.23 (9.16)	155.0 -210.6
15	Vertical fngtip rch	197.00 (8.40)	172.1 -219.2	194.32 (9.21)	160.2 -217.1
16	Forward grip rch	64.40 (2.98)	57.3 -73.2	64.37 (3.16)	56.6 -76.1
17	Forward th-tip rch	68.86 (3.40)	61.0 -78.9	68.89 (3.69)	61.1 -80.5
18	Forward fngtip rch	74.88 (3.88)	65.8 -86.4	74.50 (3.70)	66.8 -85.9
19	Span	156.38 (6.72)	134.7 -169.8	154.21 (7.96)	131.7 -171.6
20	Elbow span	80.41 (5.17)	61.8 -89.2	78.74 (5.91)	62.8 -91.6
21	Chest (bust) depth	25.11 (3.42)	15.4 -36.1	26.89 (3.41)	19.7 -36.1
22	Chest (bust) brt	27.09 (2.98)	20.1 -34.5	28.77 (3.25)	21.8 -36.9
23	Stand. e-to-e brt	44.51 (5.66)	29.3 -57.0	47.41 (4.98)	33.9 -57.6
24	Shld-elbow lgt	34.18 (2.24)	28.4 -43.8	34.12 (2.53)	28.6 -41.0
25	Shld-fngtip lgt	71.40 (3.13)	61.5 -80.1	71.71 (4.51)	61.5 -89.1
26	Shld-fist (grip axis) lgt	61.31 (3.80)	50.5 -75.1	61.34 (4.68)	51.6 -83.3
27	Foot lgt	23.40 (1.09)	19.9 -25.9	23.05 (1.28)	19.9 -26.9
28	Foot brt	9.04 (.59)	7.8 -11.7	9.05 (.66)	7.1 -10.9
29	Sit. ht(e)	85.71 (4.06)	75.3 -94.5	84.93 (3.85)	76.5 -94.5
30	Sit. ht (n)	84.91 (4.09)	74.5 -93.6	84.16 (3.99)	75.2 -94.4
31	Sit. eye ht (e)	75.40 (4.22)	64.4 -85.1	74.27 (3.71)	65.1 -84.1
32	Sit. eye ht (n)	74.62 (4.16)	63.6 -83.6	73.48 (3.65)	64.2 -83.5
33	Sit. acr. (shld) ht (e)	60.54 (3.52)	52.9 -70.8	60.50 (3.44)	49.5 -68.0
34	Sit. acr. (shld) ht (n)	59.50 (3.48)	52.5 -69.7	59.40 (3.47)	49.0 -66.8
35	Sit. elbow rest ht (n)	25.75 (3.22)	18.5 -34.5	25.83 (3.24)	16.3 -34.1

Table 5.2. Anthropometric measurements stratified by job-group (cont.).

No	Measurement	Non-manual workers (n=127)		Manual workers (n=123)	
		$\bar{x}$ (s)	min – max	$\bar{x}$ (s)	min – max
		47.54 (2.41)	42.4 -53.0	46.83 (2.63)	40.9 -53.7
37	Popliteal ht	38.18 (1.95)	34.5 -43.3	37.78 (2.02)	34.0 -43.6
38	Buttock-knee lgt	55.61 (3.01)	44.3 -62.3	55.18 (3.46)	43.2 -63.4
39	Buttock-popliteal lgt	46.26 (2.45)	40.5 -52.6	46.83 (2.65)	41.0 -55.5
40	Thigh clearance	13.56 (1.38)	10.2 -17.2	13.73 (1.67)	9.7 -19.7
41	Buttock-Leg Lgt	94.69 (4.94)	81.7 -112.4	93.74 (4.58)	83.4 -104.6
42	Sit.vertical grip rch	116.06 (4.75)	104.0 -127.8	115.51 (5.53)	104.8 -128.7
43	Sit.vertical th-tip rch	120.18 (4.83)	107.6 -132.0	119.45 (5.77)	108.6 -133.0
44	Sit.vertical fngtip rch	125.58 (5.04)	111.1 -136.7	124.50 (5.53)	113.8 -137.2
45	Sit.forward grip rch	65.41 (3.42)	57.8 -73.6	65.24 (3.19)	58.6 -73.1
46	Sit.forward th-tip rch	69.47 (3.50)	61.9 -78.6	69.44 (3.54)	62.1 -78.9
47	Sit.forward fngtip rch	75.18 (3.80)	66.0 -84.1	74.88 (3.74)	67.0 -85.4
48	Head circumf	55.36 (1.72)	51.8 -60.2	55.34 (1.74)	51.5 -60.5
49	Head lgt	17.91 (.83)	14.5 -20.4	17.82 (.88)	15.1 -20.7
50	Head brt	15.08 (.71)	13.3 -17.8	14.99 (.74)	12.4 -18.2
51	Ment-sellion (face) lgt	11.77 (.77)	9.6 -14.2	11.94 (.93)	9.3 -15.5
52	Bizygomatic (face) brt	12.65 (.67)	11.1 -15.3	12.79 (.69)	10.8 -14.5
53	Neck circumf	32.99 (2.14)	28.6 -39.4	33.90 (2.13)	29.4 -40.6
54	Chest circumf	94.08 (10.61)	70.1 -120.6	100.13 (10.58)	79.3 -126.0
55	Waist circumf	81.87 (12.33)	60.2 -115.4	89.61 (12.32)	62.9 -123.2
56	Hip brt (sit.)	37.49 (3.30)	29.7 -46.7	38.43 (3.70)	29.6 -51.1
57	Sit. e-to-e brt (n)	44.42 (5.15)	32.2 -56.7	46.91 (5.16)	34.7 -59.0
58	Shld biacr. brt	35.39 (2.20)	30.2 -41.9	35.06 (2.77)	29.2 -42.1
59	Shld bideltoid brt	40.98 (3.18)	33.1 -50.7	42.16 (3.40)	31.2 -53.3
60	Hand lgt	17.07 (.85)	15.2 -20.6	17.20 (1.06)	14.9 -20.8
61	Hand brt	7.91 (.47)	6.9 -9.8	8.04 (.53)	6.0 -9.6
62	Palm lgt perp	9.57 (.56)	6.8 -10.7	9.56 (.67)	7.3 -11.6
63	Index finger lgt	6.98 (.54)	5.8 -9.0	6.94 (.48)	5.6 -8.9
64	Hand circumf	19.21 (1.17)	16.5 -22.6	19.78 (1.08)	17.0 -22.6
65	Wrist circumf	15.94 (1.18)	13.6 -19.4	16.42 (1.20)	13.3 -19.4

e: erect body position n: normal body position

Table 5.3. Anthropometric measurements stratified by BMI-group except underweight people (all in cm except body mass).

No	Measurement	Normal weight (n= 91)		Overweight (n=154)	
		$\bar{x} (s)$	<i>min – max</i>	$\bar{x} (s)$	<i>min – max</i>
1	Body mass (kg)	56.16 (5.61)	45.0 -72.0	73.25 (11.55)	55.0 -120.0
2	Stature (e)	159.21 (6.75)	141.8 -176.1	155.48 (6.04)	142.6 -170.6
3	Stature (n)	158.76 (6.67)	141.6 -175.7	155.17 (5.98)	142.5 -170.2
4	Eye ht (e)	148.58 (6.94)	133.1 -164.9	145.05 (6.10)	131.6 -162.1
5	Eye ht (n)	147.81 (6.84)	132.6 -164.1	144.29 (6.08)	131.0 -161.5
6	Acr. (shld) ht (e)	133.22 (5.96)	119.5 -148.4	131.09 (5.60)	118.0 -144.5
7	Acr. (shld) ht (n)	132.32 (6.01)	119.1 -148.0	130.29 (6.06)	117.1 -150.8
8	Elbow ht (n)	97.54 (5.15)	76.5 -110.6	95.43 (4.81)	69.2 -108.5
9	Fngtip ht (n)	60.46 (4.12)	50.5 -75.0	58.65 (3.56)	48.6 -70.9
10	Th - tip ht (n)	66.30 (3.86)	58.0 -78.9	64.43 (3.62)	55.7 -78.0
11	Knuckle ht (n)	70.85 (4.17)	61.0 -83.0	69.09 (3.88)	54.7 -83.5
12	Waist ht (n)	91.10 (4.96)	78.3 -102.1	88.35 (5.05)	72.4 -102.4
13	Vertical grip rch	187.26 (8.84)	150.6 -208.1	184.87 (8.26)	159.1 -206.9
14	Vertical th - tip rch	192.13 (9.09)	155.0 -213.5	189.58 (8.26)	165.8 -211.5
15	Vertical fngtip rch	197.70 (9.21)	160.2 -219.2	194.63 (8.27)	172.1 -217.2
16	Forward grip rch	64.08 (2.98)	57.3 -73.2	64.72 (3.20)	56.6 -76.1
17	Forward th - tip rch	68.43 (3.40)	61.0 -78.9	69.24 (3.62)	61.1 -80.5
18	Forward fngtip rch	74.48 (3.90)	65.8 -86.4	74.97 (3.71)	66.8 -85.9
19	Span	156.53 (7.12)	131.7 -171.6	154.62 (7.34)	132.1 -170.8
20	Elbow span	80.50 (5.24)	62.8 -91.6	79.17 (5.73)	61.8 -90.9
21	Chest (bust) depth	23.19 (2.34)	15.4 -30.3	27.85 (2.84)	21.6 -36.1
22	Chest (bust) breadth	25.53 (1.99)	20.1 -31.4	29.65 (2.79)	21.8 -37.2
23	Stand. elb - to - elb breadth	41.96 (4.22)	29.3 -51.7	48.66 (4.60)	32.3 -62.1
24	Shld - elbow lgt	34.07 (2.27)	28.6 -43.8	34.28 (2.60)	28.4 -47.2
25	Shld - fngtip lgt	71.65 (3.23)	63.4 -80.8	71.65 (4.28)	61.5 -89.1
26	Shld - fist (grip axis) lgt	61.45 (3.60)	51.2 -70.0	61.40 (4.60)	50.5 -83.3
27	Foot lgt	23.23 (1.15)	19.9 -26.2	23.29 (1.22)	20.2 -26.9
28	Foot brt	8.88 (.55)	7.2 -10.3	9.17 (.65)	7.1 -11.7
29	Sit. ht(e)	86.33 (3.95)	77.1 -94.5	84.95 (3.91)	74.0 -94.5
30	Sit. ht (n)	85.63 (4.08)	76.4 -94.4	84.12 (3.91)	73.6 -93.6
31	Sit. eye ht (e)	75.54 (4.16)	64.4 -85.1	74.54 (3.80)	63.9 -84.8
32	Sit. eye ht (n)	74.76 (4.09)	63.6 -83.5	73.72 (3.74)	63.5 -83.6
33	Sit. acr. (shld) ht (e)	60.58 (3.55)	52.2 -69.0	60.64 (3.53)	49.5 -70.8
34	Sit. acr. (shld) ht (n)	59.54 (3.59)	50.4 -68.5	59.54 (3.50)	49.0 -69.7

Table 5.3. Anthropometric measurements stratified by BMI-group except underweight people (cont.).

No	Measurement	Normal weight (n= 91)		Overweight (n=154)	
		$\bar{x} (s)$	$min - max$	$\bar{x} (s)$	$min - max$
36	Knee ht	47.35 (2.47)	42.0 -53.0	47.10 (2.51)	40.9 -53.7
37	Popliteal ht	38.63 (2.12)	34.0 -43.6	37.60 (1.75)	34.2 -42.6
38	Buttock - knee lgt	55.02 (2.88)	46.9 -60.9	55.63 (3.40)	43.2 -63.4
39	Buttock - popliteal lgt	46.01 (2.46)	40.5 -51.5	46.91 (2.60)	41.0 -55.5
40	Thigh clearance	12.81 (1.12)	9.7 -15.1	14.21 (1.48)	10.5 -19.7
41	Buttock - Leg Lgt	94.75 (5.06)	84.9 -112.4	94.11 (4.45)	81.7 -104.6
42	Sit.vertical grip rch	116.48 (5.19)	104.8 -128.7	115.58 (5.10)	102.5 -128.5
43	Sit.vertical th - tip rch	120.56 (5.40)	108.6 -133.0	119.49 (5.26)	104.0 -132.2
44	Sit.vertical fngtip rch	125.85 (5.21)	113.8 -137.2	124.70 (5.27)	109.3 -136.5
45	Sit.forward grip rch	65.00 (3.35)	57.1 -73.2	65.66 (3.38)	58.6 -73.6
46	Sit.forward th - tip rch	69.21 (3.67)	61.6 -78.6	69.73 (3.51)	62.1 -78.9
47	Sit.forward fngtip rch	74.73 (3.85)	66.0 -85.4	75.35 (3.75)	67.0 -84.0
48	Head circumf	55.13 (1.51)	51.5 -59.5	55.58 (1.78)	51.8 -60.5
49	Head lgt	17.79 (.82)	14.5 -20.2	17.94 (.87)	15.1 -20.7
50	Head brt	14.96 (.65)	13.0 -17.8	15.11 (.77)	12.4 -18.2
51	Ment - sellion (face) lgt	11.76 (.82)	9.7 -14.2	11.90 (.87)	9.3 -15.5
52	Bizygomatic (face) brt	12.45 (.57)	10.8 -14.5	12.93 (.66)	10.8 -15.3
53	Neck circumf	31.80 (1.45)	28.6 -34.9	34.58 (1.92)	30.2 -40.6
54	Chest circumf	88.12 (5.38)	77.4 -102.1	103.42 (9.22)	84.0 -127.2
55	Waist circumf	75.05 (6.45)	60.2 -90.0	93.11 (10.97)	70.5 -123.2
56	Hip brt (sit.)	35.48 (2.37)	29.6 -40.5	39.61 (3.04)	34.0 -51.1
57	Sit. e - to - e brt (n)	41.80 (3.47)	32.2 -50.3	48.30 (4.65)	34.0 -59.0
58	Shld biacr. brt	34.64 (2.68)	29.2 -41.9	35.43 (2.52)	27.7 -42.1
59	Shld bideltoid brt	39.54 (2.46)	31.2 -46.5	42.97 (3.08)	34.5 -53.3
60	Hand lgt	17.04 (.77)	14.9 -19.0	17.24 (1.08)	14.9 -20.8
61	Hand brt	7.78 (.44)	6.2 -9.3	8.12 (.51)	6.0 -9.8
62	Palm lgt perp	9.48 (.58)	7.8 -11.0	9.62 (.65)	6.8 -11.6
63	Index finger lgt	6.95 (.46)	6.1 -8.0	6.98 (.55)	5.6 -9.0
64	Hand circumf	18.91 (.92)	16.9 -20.8	19.95 (1.10)	16.6 -22.6
65	Wrist circumf	15.33 (.83)	13.3 -17.1	16.75 (1.07)	13.3 -19.4

5.1.2. Percentile Values

The percentiles below show the values of each measurement, which are greater than or equal to a certain percent of observations.

Equation 5.1 shows calculation of the value of a percentile;

$$\text{The value of } p^{th} \text{ percentile} = \bar{x} + (Z_p \times s) \quad (5.1)$$

As an example, the calculation of 95th percentile value for the case of weight with $\bar{x}=66.50$ kg and $s =12.99$ kg, is presented below:

$$\begin{aligned} \text{the value of 95}^{th} \text{ percentile} &= 66.50 + (Z_{0.95} \times 12.99) \\ &= 66.50 + (1.645 \times 12.99) \\ &= 87.93 \text{ kg} \end{aligned}$$

which means that 95 % of the female weight is below 87.93 kg and only 5 % is above it.

5th, 50th, and 95th percentile values with standard deviation statistics for age group, job-group and BMI-group (in which underweight people were excluded since there were only 5 people in underweight group and it is not sufficient to conclude accurate results) were calculated as given in Table 5.4, Table 5.5 and Table 5.6.

Table 5.4. Percentiles for subjects' anthropometric characteristics stratified by age-group.

	Overall (n=250)				18-29 yrs (n=55)				30-39 yrs (n=52)				40-49 yrs (n=48)				50-59 yrs (n=50)				60-79 yrs (n=45)			
Meas.	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd
Body Mass (kg)	45.07	66.50	87.93	12.99	40.69	59.19	77.70	11.22	43.06	65.96	88.86	13.88	46.91	64.85	82.80	10.88	51.85	71.60	91.35	11.97	51.03	72.16	93.29	12.81
Stature (e)	146.09	157.02	167.95	6.62	149.42	160.67	171.91	6.82	150.32	158.55	166.79	4.99	144.63	154.81	165.00	6.17	146.45	156.58	166.71	6.14	142.63	153.63	164.63	6.67
Stature (n)	145.87	156.65	167.44	6.54	149.19	160.26	171.32	6.70	149.91	158.15	166.39	4.99	144.41	154.43	164.44	6.07	146.31	156.26	166.21	6.03	142.38	153.32	164.26	6.63
Eye ht (e)	135.43	146.51	157.58	6.71	138.56	150.32	162.07	7.12	139.30	147.76	156.21	5.12	134.15	144.25	154.36	6.13	135.95	146.19	156.43	6.21	132.26	143.16	154.06	6.61
Eye ht (n)	134.76	145.73	156.71	6.65	137.89	149.41	160.92	6.98	138.35	146.89	155.43	5.18	133.49	143.58	153.68	6.12	135.26	145.52	155.77	6.21	131.58	142.45	153.32	6.59
Acr. (shld) ht (e)	122.30	132.00	141.69	5.88	124.86	134.70	144.54	5.97	124.74	132.74	140.74	4.85	120.50	129.74	138.97	5.60	123.19	132.17	141.15	5.44	119.49	130.05	140.60	6.40
Acr. (shld) ht (n)	121.03	131.15	141.27	6.13	123.94	133.65	143.36	5.88	123.54	131.64	139.74	4.91	119.59	128.76	137.93	5.56	121.71	131.40	141.10	5.88	117.44	129.78	142.12	7.48
Elbow ht (n)	87.97	96.28	104.58	5.03	88.35	97.98	107.62	5.84	90.85	97.50	104.15	4.03	86.19	94.81	103.44	5.23	88.89	96.25	103.60	4.46	86.62	94.36	102.10	4.69
Fngtip ht (n)	52.91	59.36	65.82	3.91	54.69	61.63	68.57	4.20	54.77	60.06	65.35	3.21	52.33	58.10	63.87	3.50	53.50	59.06	64.61	3.37	51.01	57.47	63.93	3.92
Th-tip ht (n)	58.82	65.19	71.56	3.86	60.53	67.19	73.84	4.03	60.44	65.94	71.44	3.33	58.84	64.19	69.54	3.24	59.17	64.93	70.69	3.49	56.60	63.23	69.87	4.02
Fist(gr.ax. knck)ht (n)	63.00	69.80	76.60	4.12	65.51	72.03	78.55	3.95	64.06	70.23	76.39	3.74	62.64	68.81	74.99	3.74	63.65	69.62	75.58	3.62	60.41	67.86	75.30	4.51
Waist ht (n)	80.86	89.52	98.18	5.25	82.74	91.27	99.81	5.17	83.68	91.13	98.58	4.52	80.79	88.89	96.98	4.90	80.74	89.24	97.74	5.15	77.77	86.50	95.24	5.29
Vertical grip rch	171.79	185.92	200.04	8.56	175.93	189.26	202.58	8.08	176.17	187.65	199.14	6.96	170.97	183.55	196.14	7.63	175.24	186.85	198.46	7.04	163.85	181.32	198.78	10.59
Vertical th-tip rch	176.40	190.68	204.95	8.65	180.29	194.10	207.92	8.37	181.13	192.36	203.58	6.80	175.26	188.51	201.77	8.03	179.72	191.52	203.32	7.15	168.59	185.92	203.24	10.50
Vertical fngtip rch	181.46	195.93	210.40	8.77	185.77	199.84	213.90	8.53	186.33	197.55	208.77	6.80	180.37	193.78	207.19	8.13	184.75	196.56	208.37	7.16	173.56	190.87	208.18	10.49
Forward grip rch	59.38	64.52	69.65	3.11	60.40	65.01	69.62	2.79	59.49	63.97	68.45	2.72	59.31	63.85	68.39	2.75	60.03	65.03	70.03	3.03	57.80	64.67	71.55	4.17
Forward th-tip rch	63.14	68.99	74.84	3.55	64.26	69.81	75.35	3.36	63.02	68.38	73.74	3.25	62.55	68.41	74.27	3.55	64.08	69.43	74.78	3.24	61.76	68.82	75.89	4.28
Forward fngtip rch	68.60	74.81	81.02	3.76	69.36	75.94	82.52	3.99	68.64	74.36	80.07	3.46	68.61	73.95	79.29	3.24	69.69	75.27	80.85	3.38	66.85	74.38	81.91	4.56
Span	143.43	155.46	167.50	7.29	146.88	157.63	168.38	6.52	145.48	156.69	167.89	6.79	143.12	154.22	165.32	6.73	144.22	155.82	167.42	7.03	138.60	152.32	166.05	8.32
Elbow span	70.55	79.73	88.92	5.56	73.57	81.65	89.74	4.90	72.41	80.83	89.26	5.11	67.46	78.08	88.70	6.44	72.31	80.30	88.29	4.84	68.17	77.25	86.33	5.50
Chest (bust) depth	20.22	26.02	31.83	3.52	19.28	23.68	28.08	2.66	19.50	25.06	30.63	3.37	21.02	25.79	30.55	2.89	22.79	27.90	33.00	3.10	22.81	28.16	33.51	3.24
Chest (bust) brt	22.59	28.01	33.43	3.28	21.60	25.73	29.86	2.50	22.69	27.15	31.60	2.70	23.51	27.88	32.25	2.65	24.38	29.58	34.78	3.15	24.93	30.18	35.43	3.18
Stand. e-to-e brt	36.77	46.00	55.23	5.59	34.23	41.65	49.06	4.50	36.63	44.78	52.94	4.94	38.26	46.36	54.45	4.91	39.92	47.93	55.93	4.85	42.99	50.21	57.44	4.38
Shld-elbow lgt	30.14	34.24	38.34	2.49	30.60	34.69	38.78	2.48	30.64	33.88	37.12	1.96	30.06	33.18	36.31	1.90	30.28	34.94	39.60	2.82	29.84	34.46	39.07	2.80

Table 5.4. Percentiles for subjects' anthropometric characteristics stratified by age-group (cont.).

	Overall (n=250)				18-29 yrs (n=55)				30-39 yrs (n=52)				40-49 yrs (n=48)				50-59 yrs (n=50)				60-79 yrs (n=45)			
Meas.	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd
Shld-fngtip lgt	65.27	71.72	78.17	3.91	66.48	71.83	77.19	3.25	65.86	71.45	77.04	3.39	64.50	70.65	76.80	3.73	64.62	72.51	80.41	4.79	65.36	72.13	78.90	4.10
Shld-fist (grip axis) lgt	54.50	61.47	68.43	4.22	55.69	61.91	68.12	3.77	55.10	61.31	67.52	3.76	53.98	59.94	65.91	3.61	55.40	61.98	68.56	3.99	52.90	62.16	71.42	5.61
Foot lgt	21.32	23.28	25.25	1.19	21.86	23.61	25.36	1.06	21.47	23.39	25.32	1.16	21.05	23.17	25.28	1.28	21.94	23.37	24.80	0.87	20.58	22.78	24.99	1.34
Foot brt	8.03	9.06	10.10	0.63	8.00	8.95	9.90	0.58	7.94	8.97	9.99	0.62	8.06	9.18	10.30	0.68	8.26	9.21	10.16	0.58	8.08	9.02	9.97	0.57
Sit. ht(e)	78.91	85.47	92.03	3.97	80.36	87.05	93.73	4.05	80.59	86.90	93.21	3.82	78.71	84.74	90.76	3.65	79.32	84.80	90.28	3.32	77.00	83.42	89.84	3.89
Sit. ht (n)	78.01	84.68	91.36	4.04	79.42	86.19	92.96	4.10	79.62	86.06	92.49	3.90	77.55	84.10	90.64	3.97	78.47	83.98	89.49	3.34	76.19	82.66	89.13	3.92
Sit. eye ht (e)	68.39	74.94	81.49	3.97	69.05	76.48	83.91	4.50	69.74	76.13	82.53	3.88	68.47	74.15	79.83	3.44	68.89	74.14	79.39	3.18	66.97	73.41	79.85	3.90
Sit. eye ht (n)	67.69	74.14	80.59	3.91	68.35	75.65	82.96	4.43	69.04	75.34	81.64	3.82	67.69	73.28	78.87	3.39	68.15	73.36	78.57	3.16	66.36	72.69	79.01	3.83
Sit. acr. (shld) ht (e)	54.80	60.61	66.41	3.52	55.39	61.17	66.94	3.50	54.71	61.04	67.38	3.84	54.42	60.42	66.43	3.64	55.59	60.54	65.50	3.00	53.66	59.68	65.71	3.65
Sit. acr. (shld) ht (n)	53.74	59.53	65.32	3.51	54.16	60.01	65.87	3.55	53.68	59.93	66.18	3.79	53.38	59.35	65.31	3.62	54.28	59.40	64.52	3.10	52.93	58.81	64.68	3.56
Sit. elbow rest ht (n)	20.55	25.86	31.17	3.22	21.13	26.12	31.10	3.02	20.66	26.36	32.06	3.45	20.22	26.20	32.18	3.63	21.52	25.50	29.48	2.41	19.16	25.00	30.84	3.54
Knee ht	43.11	47.24	51.38	2.51	44.29	48.19	52.08	2.36	43.71	47.39	51.07	2.23	42.40	46.60	50.80	2.55	43.64	47.40	51.17	2.28	41.82	46.43	51.04	2.79
Popliteal ht	34.76	38.02	41.28	1.98	36.18	39.24	42.31	1.86	34.93	38.02	41.10	1.87	34.97	37.60	40.22	1.59	34.39	37.91	41.44	2.14	34.27	37.11	39.95	1.72
Buttock-knee lgt	50.13	55.43	60.72	3.21	51.12	55.67	60.21	2.76	51.81	55.87	59.94	2.46	48.91	54.42	59.94	3.34	50.48	55.82	61.17	3.24	48.71	55.26	61.81	3.97
Buttock-popliteal lgt	42.35	46.57	50.79	2.56	42.07	45.87	49.67	2.30	42.93	46.54	50.15	2.19	41.67	45.81	49.94	2.51	43.36	47.20	51.05	2.33	42.48	47.55	52.63	3.08
Thigh clearance	11.12	13.65	16.18	1.53	10.84	13.02	15.19	1.32	11.31	14.15	16.98	1.72	11.31	13.61	15.91	1.39	11.55	13.84	16.13	1.39	11.03	13.68	16.33	1.61
Buttock-Leg lgt	86.65	94.45	102.24	4.72	87.80	96.24	104.68	5.11	88.82	94.47	100.11	3.42	85.12	92.81	100.50	4.66	87.95	94.96	101.98	4.25	84.23	93.40	102.57	5.56
Sit.vertical grip rch	107.48	115.93	124.38	5.12	109.20	117.20	125.21	4.85	108.87	116.51	124.14	4.63	106.59	114.76	122.93	4.95	107.86	116.51	125.15	5.24	105.04	114.32	123.60	5.63
Sit.vertical th-tip rch	111.17	119.90	128.64	5.29	113.47	121.54	129.62	4.90	112.68	120.64	128.60	4.82	110.25	118.71	127.16	5.13	111.73	120.49	129.24	5.31	108.24	117.68	127.13	5.72
Sit.vertical fngtip rch	116.50	125.16	133.82	5.25	118.56	127.06	135.56	5.15	118.11	126.00	133.89	4.78	115.72	123.73	131.73	4.85	117.30	125.59	133.88	5.02	113.60	122.94	132.29	5.66
Sit.forward grip rch	59.88	65.46	71.04	3.38	60.07	65.67	71.27	3.39	60.07	65.05	70.03	3.02	58.99	65.19	71.39	3.76	61.20	65.53	69.87	2.63	59.02	65.88	72.74	4.16
Sit.forward th-tip rch	63.67	69.60	75.52	3.59	63.97	69.97	75.97	3.64	64.09	69.24	74.40	3.12	62.37	69.15	75.94	4.11	65.02	69.82	74.62	2.91	62.74	69.76	76.78	4.25
Sit.forward fngtip rch	68.91	75.19	81.47	3.81	69.36	75.83	82.30	3.92	69.29	74.98	80.67	3.45	67.58	74.55	81.52	4.22	70.20	75.39	80.57	3.14	67.84	75.09	82.35	4.40

Table 5.4. Percentiles for subjects' anthropometric characteristics stratified by age-group (cont.).

	Overall (n=250)				18-29 yrs (n=55)				30-39 yrs (n=52)				40-49 yrs (n=48)				50-59 yrs (n=50)				60-79 yrs (n=45)			
Meas.	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd	5	50	95	sd
Head circumf	52.61	55.40	58.18	1.69	52.60	55.20	57.80	1.58	52.71	55.53	58.34	1.70	52.38	55.30	58.22	1.77	52.58	55.51	58.44	1.77	52.89	55.46	58.03	1.56
Head lgt	16.48	17.89	19.30	0.85	16.43	17.94	19.44	0.91	16.63	17.90	19.18	0.77	16.54	17.93	19.32	0.84	16.46	17.74	19.03	0.78	16.56	17.94	19.32	0.84
Head brt	13.83	15.04	16.25	0.73	13.72	15.11	16.49	0.84	14.01	15.00	16.00	0.60	13.85	14.97	16.08	0.67	13.98	15.03	16.08	0.64	13.88	15.09	16.30	0.73
Ment-sellion (face) lgt	10.45	11.84	13.23	0.84	10.29	11.72	13.14	0.86	10.71	11.89	13.07	0.71	10.61	11.89	13.17	0.78	10.31	11.75	13.20	0.88	10.67	11.99	13.31	0.80
Bizygomatic (face) brt	11.62	12.73	13.85	0.68	11.31	12.47	13.63	0.71	11.78	12.78	13.78	0.61	11.59	12.57	13.55	0.59	11.87	12.88	13.89	0.61	11.88	13.01	14.14	0.68
Neck circumf	29.81	33.49	37.17	2.23	28.77	32.16	35.56	2.06	29.63	33.16	36.69	2.14	30.00	33.38	36.76	2.05	31.44	34.26	37.09	1.71	31.27	34.74	38.22	2.11
Chest circumf	78.84	97.32	115.79	11.20	75.28	89.41	103.55	8.57	79.00	94.08	109.16	9.14	82.48	96.70	110.92	8.62	84.91	102.94	120.98	10.93	88.25	105.11	121.98	10.22
Waist circumf	64.24	85.97	107.70	13.17	60.86	75.60	90.34	8.93	64.15	82.21	100.26	10.94	68.94	84.04	99.14	9.15	73.11	92.44	111.76	11.71	78.97	97.87	116.77	11.45
Hip brt (sit.)	32.17	37.96	43.76	3.51	31.43	36.13	40.83	2.85	31.50	37.80	44.10	3.82	32.79	37.76	42.74	3.02	33.37	39.27	45.17	3.58	34.09	39.16	44.23	3.07
Sit. e-to-e brt (n)	36.99	45.75	54.52	5.31	35.85	41.87	47.89	3.65	36.09	44.72	53.35	5.23	38.76	45.71	52.66	4.21	39.72	47.50	55.28	4.72	41.82	49.80	57.78	4.84
Shld biacr. brt	30.83	35.11	39.38	2.59	31.70	35.13	38.56	2.08	30.36	35.23	40.09	2.95	31.27	35.38	39.50	2.49	30.45	35.05	39.65	2.79	30.33	34.72	39.12	2.66
Shld bideltoid brt	36.04	41.59	47.14	3.36	35.64	39.80	43.96	2.52	36.10	41.58	47.06	3.32	36.50	41.66	46.82	3.13	36.94	42.49	48.04	3.37	36.81	42.72	48.63	3.58
Hand lgt	15.56	17.17	18.77	0.97	15.22	17.19	19.16	1.20	15.95	17.29	18.63	0.81	15.69	17.07	18.45	0.84	15.67	17.30	18.93	0.99	15.41	16.94	18.48	0.93
Hand brt	7.14	7.98	8.82	0.51	6.95	7.72	8.49	0.46	7.11	7.90	8.68	0.48	7.30	8.00	8.70	0.43	7.41	8.20	8.99	0.48	7.38	8.13	8.88	0.45
Palm lgt perp	8.53	9.57	10.61	0.63	8.50	9.49	10.48	0.60	8.75	9.69	10.63	0.57	8.46	9.45	10.43	0.60	8.60	9.65	10.71	0.64	8.35	9.56	10.77	0.73
Index finger lgt	6.12	6.97	7.82	0.52	6.21	7.12	8.03	0.55	6.16	6.94	7.72	0.47	6.08	6.97	7.87	0.54	6.22	7.06	7.89	0.51	6.06	6.74	7.42	0.41
Hand circumf	17.59	19.53	21.46	1.17	17.14	18.84	20.54	1.03	17.46	19.35	21.23	1.14	17.89	19.63	21.36	1.05	18.41	20.02	21.63	0.97	17.97	19.92	21.86	1.18
Wrist circumf	14.18	16.19	18.21	1.22	13.84	15.37	16.91	0.93	13.81	16.06	18.31	1.36	14.73	16.28	17.84	0.94	14.72	16.58	18.44	1.13	15.03	16.83	18.62	1.09

Table 5.5. Percentiles for subjects' anthropometric characteristics stratified by job-group.

	Non-manual workers (n=127)				Manual workers (n=123)			
Dimension	5	50	95	sd	5	50	95	sd
Body mass (kg)	43.45	63.75	84.06	12.31	47.62	68.70	89.78	12.77
Stature (e)	146.84	157.92	169.01	6.72	144.67	155.72	166.76	6.69
Stature (n)	146.61	157.54	168.47	6.63	144.48	155.38	166.27	6.60
Eye ht (e)	136.04	147.32	158.60	6.84	134.13	145.26	156.39	6.74
Eye ht (n)	135.36	146.52	157.68	6.77	133.44	144.50	155.56	6.70
Acr. (shld) ht (e)	122.75	132.38	142.01	5.84	121.25	131.16	141.08	6.01
Acr. (shld) ht (n)	121.56	131.24	140.92	5.87	119.71	130.52	141.34	6.55
Elbow ht (n)	87.68	96.51	105.33	5.35	87.26	95.64	104.01	5.08
Fngtip ht (n)	52.92	59.81	66.70	4.17	52.68	58.71	64.73	3.65
Th-tip ht (n)	58.95	65.55	72.16	4.00	58.57	64.72	70.87	3.73
Fist(gr.ax, knck)ht (n)	62.75	70.05	77.36	4.43	62.93	69.29	75.66	3.86
Waist ht (n)	82.01	90.36	98.70	5.06	79.55	88.45	97.36	5.40
Vertical grip rch	173.52	186.86	200.20	8.08	169.47	184.50	199.53	9.11
Vertical th-tip rch	178.13	191.63	205.12	8.18	174.11	189.23	204.35	9.16
Vertical fngtip rch	183.13	197.00	210.87	8.40	179.12	194.32	209.52	9.21
Forward grip rch	59.48	64.40	69.32	2.98	59.16	64.37	69.59	3.16
Forward th-tip rch	63.24	68.86	74.47	3.40	62.80	68.89	74.98	3.69
Forward fngtip rch	68.48	74.88	81.28	3.88	68.40	74.50	80.60	3.70
Span	145.30	156.38	167.47	6.72	141.08	154.21	167.34	7.96
Elbow span	71.87	80.41	88.95	5.17	68.99	78.74	88.50	5.91
Chest (bust) depth	19.47	25.11	30.75	3.42	21.26	26.89	32.52	3.41
Chest (bust) brt	22.17	27.09	32.01	2.98	23.40	28.77	34.14	3.25
Stand. e-to-e brt	35.17	44.51	53.84	5.66	39.19	47.41	55.62	4.98
Shld-elbow lgt	30.48	34.18	37.88	2.24	29.95	34.12	38.30	2.53
Shld-fngtip lgt	66.23	71.40	76.56	3.13	64.27	71.71	79.16	4.51
Shld-fist (grip axis) lgt	55.04	61.31	67.59	3.80	53.62	61.34	69.06	4.68
Foot lgt	21.60	23.40	25.19	1.09	20.94	23.05	25.16	1.28
Foot brt	8.06	9.04	10.01	0.59	7.96	9.05	10.14	0.66
Sit. ht(e)	79.02	85.71	92.40	4.06	78.58	84.93	91.29	3.85
Sit. ht (n)	78.15	84.91	91.66	4.09	77.58	84.16	90.74	3.99
Sit. eye ht (e)	68.43	75.40	82.37	4.22	68.15	74.27	80.39	3.71
Sit. eye ht (n)	67.77	74.62	81.48	4.16	67.46	73.48	79.51	3.65
Sit. acr. (shld) ht (e)	54.72	60.54	66.35	3.52	54.82	60.50	66.18	3.44
Sit. acr. (shld) ht (n)	53.75	59.50	65.24	3.48	53.67	59.40	65.13	3.47

Table 5.5. Percentiles for subjects' anthropometric characteristics stratified by job-group (cont.).

	Non-manual workers (n=127)				Manual workers (n=123)			
Dimension	5	50	95	sd	5	50	95	sd
Sit. elbow rest ht (n)	20.43	25.75	31.07	3.22	20.49	25.83	31.17	3.24
Knee ht	43.56	47.54	51.52	2.41	42.48	46.83	51.18	2.63
Popliteal ht	34.96	38.18	41.39	1.95	34.45	37.78	41.11	2.02
Buttock-knee lgt	50.64	55.61	60.58	3.01	49.46	55.18	60.89	3.46
Buttock-popliteal lgt	42.21	46.26	50.30	2.45	42.46	46.83	51.21	2.65
Thigh clearance	11.29	13.56	15.84	1.38	10.97	13.73	16.49	1.67
Buttock-Leg Lgt	86.54	94.69	102.84	4.94	86.19	93.74	101.29	4.58
Sit.vertical grip rch	108.23	116.06	123.90	4.75	106.39	115.51	124.64	5.53
Sit.vertical th-tip rch	112.20	120.18	128.15	4.83	109.93	119.45	128.96	5.77
Sit.vertical fngtip rch	117.26	125.58	133.90	5.04	115.37	124.50	133.63	5.53
Sit.forward grip rch	59.76	65.41	71.06	3.42	59.97	65.24	70.50	3.19
Sit.forward th-tip rch	63.70	69.47	75.24	3.50	63.60	69.44	75.27	3.54
Sit.forward fngtip rch	68.91	75.18	81.46	3.80	68.70	74.88	81.06	3.74
Head circumf	52.53	55.36	58.20	1.72	52.47	55.34	58.22	1.74
Head lgt	16.53	17.91	19.28	0.83	16.37	17.82	19.27	0.88
Head brt	13.91	15.08	16.25	0.71	13.77	14.99	16.22	0.74
Ment-sellion (face) lgt	10.51	11.77	13.04	0.77	10.40	11.94	13.48	0.93
Bizygomatic (face) brt	11.56	12.65	13.75	0.67	11.66	12.79	13.93	0.69
Neck circumf	29.47	32.99	36.52	2.14	30.38	33.90	37.42	2.13
Chest circumf	76.57	94.08	111.59	10.61	82.67	100.13	117.60	10.58
Waist circumf	61.53	81.87	102.21	12.33	69.29	89.61	109.93	12.32
Hip brt (sit.)	32.05	37.49	42.92	3.30	32.33	38.43	44.53	3.70
Sit. e-to-e brt (n)	35.91	44.42	52.92	5.15	38.40	46.91	55.42	5.16
Shld biacr. brt	31.76	35.39	39.01	2.20	30.50	35.06	39.63	2.77
Shld bideltoid brt	35.74	40.98	46.22	3.18	36.55	42.16	47.78	3.40
Hand lgt	15.68	17.07	18.47	0.85	15.45	17.20	18.96	1.06
Hand brt	7.12	7.91	8.69	0.47	7.15	8.04	8.92	0.53
Palm lgt perp	8.65	9.57	10.49	0.56	8.44	9.56	10.67	0.67
Index finger lgt	6.09	6.98	7.88	0.54	6.14	6.94	7.74	0.48
Hand circumf	17.27	19.21	21.14	1.17	18.00	19.78	21.57	1.08
Wrist circumf	14.00	15.94	17.88	1.18	14.43	16.42	18.40	1.20

Table 5.6. Percentiles for subjects' anthro. characteristics stratified by BMI-group.

	Normal weight (n= 91)				Over weight (n=154)			
Dimension	5	50	95	<i>sd</i>	5	50	95	<i>sd</i>
Body mass (kg)	46.90	56.16	65.42	5.61	54.20	73.25	92.31	11.55
Stature (e)	148.08	159.21	170.34	6.75	145.51	155.48	165.45	6.04
Stature (n)	147.76	158.76	169.76	6.67	145.30	155.17	165.03	5.98
Eye ht (e)	137.13	148.58	160.03	6.94	134.99	145.05	155.12	6.10
Eye ht (n)	136.53	147.81	159.09	6.84	134.26	144.29	154.31	6.08
Acr. (shld) ht (e)	123.39	133.22	143.05	5.96	121.86	131.09	140.33	5.60
Acr. (shld) ht (n)	122.41	132.32	142.23	6.01	120.30	130.29	140.28	6.06
Elbow ht (n)	89.03	97.54	106.04	5.15	87.49	95.43	103.36	4.81
Fngtip ht (n)	53.66	60.46	67.26	4.12	52.79	58.65	64.52	3.56
Th-tip ht (n)	59.93	66.30	72.68	3.86	58.46	64.43	70.41	3.62
Fist(gr.ax, knck)ht (n)	63.98	70.85	77.73	4.17	62.69	69.09	75.49	3.88
Waist ht (n)	82.92	91.10	99.28	4.96	80.02	88.35	96.68	5.05
Vertical grip rch	172.67	187.26	201.85	8.84	171.24	184.87	198.50	8.26
Vertical th-tip rch	177.13	192.13	207.13	9.09	175.95	189.58	203.21	8.26
Vertical fngtip rch	182.50	197.70	212.89	9.21	180.97	194.63	208.28	8.27
Forward grip rch	59.16	64.08	69.00	2.98	59.44	64.72	70.00	3.20
Forward th-tip rch	62.82	68.43	74.05	3.40	63.26	69.24	75.22	3.62
Forward fngtip rch	68.05	74.48	80.91	3.90	68.85	74.97	81.08	3.71
Span	144.79	156.53	168.27	7.12	142.51	154.62	166.74	7.34
Elbow span	71.85	80.50	89.16	5.24	69.71	79.17	88.63	5.73
Chest (bust) depth	19.34	23.19	27.05	2.34	23.16	27.85	32.53	2.84
Chest (bust) brt	22.25	25.53	28.81	1.99	25.05	29.65	34.26	2.79
Stand. e-to-e brt	35.00	41.96	48.93	4.22	41.06	48.66	56.25	4.60
Shld-elbow lgt	30.33	34.07	37.82	2.27	29.99	34.28	38.56	2.60
Shld-fngtip lgt	66.33	71.65	76.98	3.23	64.58	71.65	78.71	4.28
Shld-fist (grip axis) lgt	55.52	61.45	67.39	3.60	53.81	61.40	68.99	4.60
Foot lgt	21.34	23.23	25.13	1.15	21.28	23.29	25.31	1.22
Foot brt	7.97	8.88	9.80	0.55	8.10	9.17	10.25	0.65
Sit. ht(e)	79.82	86.33	92.84	3.95	78.50	84.95	91.39	3.91
Sit. ht (n)	78.91	85.63	92.36	4.08	77.66	84.12	90.58	3.91
Sit. eye ht (e)	68.67	75.54	82.40	4.16	68.27	74.54	80.81	3.80
Sit. eye ht (n)	68.01	74.76	81.52	4.09	67.56	73.72	79.89	3.74
Sit. acr. (shld) ht (e)	54.72	60.58	66.44	3.55	54.82	60.64	66.46	3.53
Sit. acr. (shld) ht (n)	53.62	59.54	65.46	3.59	53.77	59.54	65.31	3.50
Sit. elbow rest ht (n)	20.28	25.65	31.02	3.25	20.82	26.06	31.30	3.17

Table 5.6. Percentiles for subjects' anthro. characteristics stratified by BMI-group (cont.).

	Normal weight (n= 91)				Over weight (n=154)			
Dimension	5	50	95	<i>sd</i>	5	50	95	<i>sd</i>
Knee ht	43.26	47.35	51.43	2.47	42.95	47.10	51.25	2.51
Popliteal ht	35.13	38.63	42.13	2.12	34.71	37.60	40.50	1.75
Buttock-knee lgt	50.26	55.02	59.78	2.88	50.01	55.63	61.25	3.40
Buttock-popliteal lgt	41.95	46.01	50.07	2.46	42.62	46.91	51.19	2.60
Thigh clearance	10.96	12.81	14.66	1.12	11.77	14.21	16.66	1.48
Buttock-Leg Lgt	86.40	94.75	103.11	5.06	86.76	94.11	101.45	4.45
Sit.vertical grip rch	107.91	116.48	125.05	5.19	107.17	115.58	123.99	5.10
Sit.vertical th-tip rch	111.66	120.56	129.46	5.40	110.82	119.49	128.16	5.26
Sit.vertical fngtip rch	117.26	125.85	134.45	5.21	116.01	124.70	133.39	5.27
Sit.forward grip rch	59.47	65.00	70.52	3.35	60.09	65.66	71.24	3.38
Sit.forward th-tip rch	63.15	69.21	75.27	3.67	63.94	69.73	75.52	3.51
Sit.forward fngtip rch	68.38	74.73	81.09	3.85	69.15	75.35	81.54	3.75
Head circumf	52.64	55.13	57.62	1.51	52.65	55.58	58.51	1.78
Head lgt	16.43	17.79	19.15	0.82	16.50	17.94	19.38	0.87
Head brt	13.88	14.96	16.03	0.65	13.84	15.11	16.37	0.77
Ment-sellion (face) lgt	10.41	11.76	13.11	0.82	10.47	11.90	13.33	0.87
Bizygomatic (face) brt	11.51	12.45	13.40	0.57	11.84	12.93	14.01	0.66
Neck circumf	29.42	31.80	34.19	1.45	31.42	34.58	37.74	1.92
Chest circumf	79.24	88.12	97.00	5.38	88.20	103.42	118.63	9.22
Waist circumf	64.40	75.05	85.70	6.45	75.01	93.11	111.22	10.97
Hip brt (sit.)	31.57	35.48	39.40	2.37	34.59	39.61	44.63	3.04
Sit. e-to-e brt (n)	36.08	41.80	47.52	3.47	40.63	48.30	55.97	4.65
Shld biacr. brt	30.22	34.64	39.05	2.68	31.26	35.43	39.59	2.52
Shld bideltoid brt	35.47	39.54	43.60	2.46	37.89	42.97	48.06	3.08
Hand lgt	15.76	17.04	18.31	0.77	15.47	17.24	19.02	1.08
Hand brt	7.06	7.78	8.50	0.44	7.27	8.12	8.96	0.51
Palm lgt perp	8.53	9.48	10.44	0.58	8.54	9.62	10.70	0.65
Index finger lgt	6.19	6.95	7.71	0.46	6.08	6.98	7.89	0.55
Hand circumf	17.39	18.91	20.43	0.92	18.14	19.95	21.76	1.10
Wrist circumf	13.95	15.33	16.70	0.83	14.99	16.75	18.51	1.07

5.1.3. Box-plots of Body Measures Stratified by Independent Factors

5.1.3.1. Age-Group. Figure 5.1 shows the box-plots of subjects' body mass according to age groups. It is seen from the plot that body mass increases up to group (30-39), stays about the same until group (40-49), then increases for (50-59) and stays about the same for (60-79).

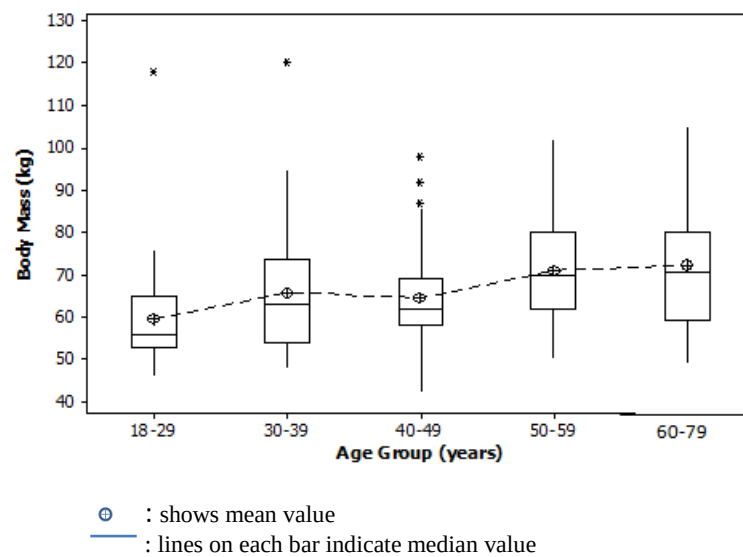


Figure 5.1. Box-plots of body mass of subjects stratified by age-group.

Figure 5.2 shows the box-plots of subjects' stature in normal position according to age groups. It is seen from the plot that stature decreases with increasing age, except an increase between groups (40-49) and (50-59).

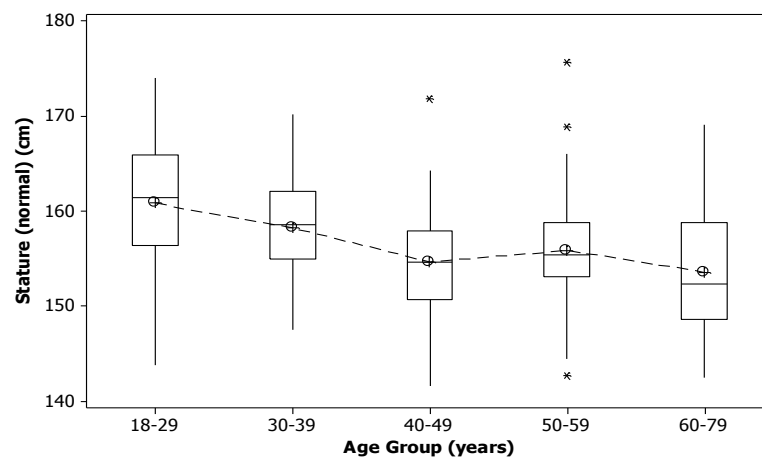


Figure 5.2. Box-plots of stature in normal position of subjects stratified by age-group.

5.1.3.2. Job-Group. Figure 5.3 shows the box-plots of body mass according to job groups. According to the figure, manual workers are heavier than non-manual workers. This result may be due to high number of housewives in manual job-group. It is seen from Figure 5.4 and Figure 5.5 that there are differences in stature and sitting height between groups. Both dimensions are higher for non-manual workers.

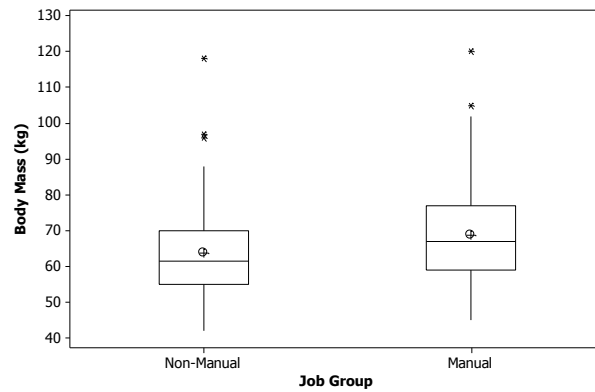


Figure 5.3. Box-plots of body mass of subjects stratified by job-group.

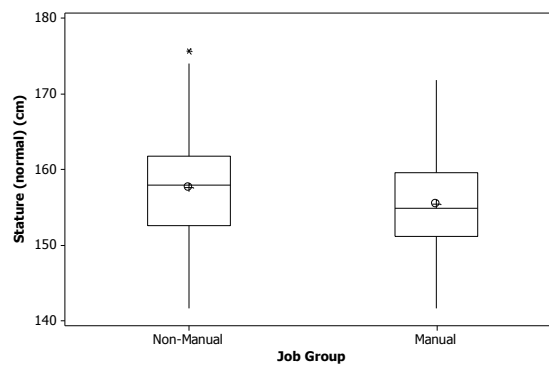


Figure 5.4. Box-plots of stature in normal position of subjects stratified by job-group.



Figure 5.5. Box-plots of sitting height of subjects stratified by job-group.

5.1.3.3. BMI-Group. Underweight people were excluded from the analyses of BMI-group effect on the anthropometric measurements since there were only five subjects in this study and it is not sufficient to generalize the results of this group. Figure 5.6 shows the result of BMI-group effect on chest circumference. Also, in Figure 5.7, the effect of BMI-group on waist circumference is shown.

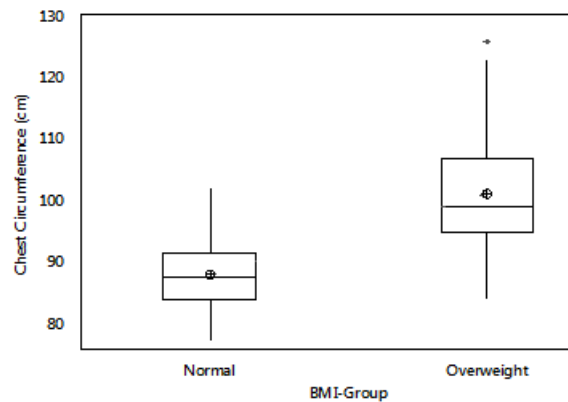


Figure 5.6. Box-plots of chest circumference of subjects stratified by BMI-group (excluded underweight people).

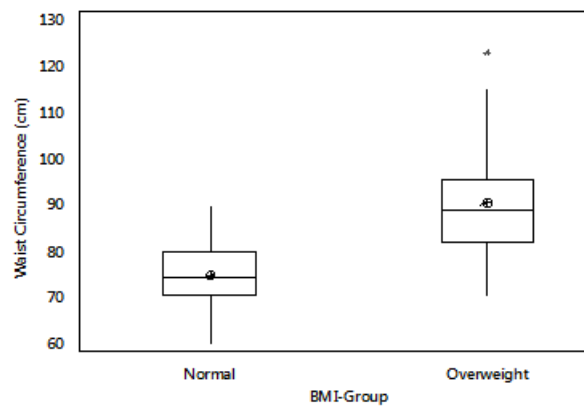


Figure 5.7. Box-plots of waist circumference of subjects stratified by BMI-group (excluded underweight people).

5.1.4. Distributions of Anthropometric Measurements

Figure 5.8 shows distributions for some anthropometric measurements including body mass, stature, waist circumference, sitting height, foot length and hand length (cm). All of them have skewed normal distributions.

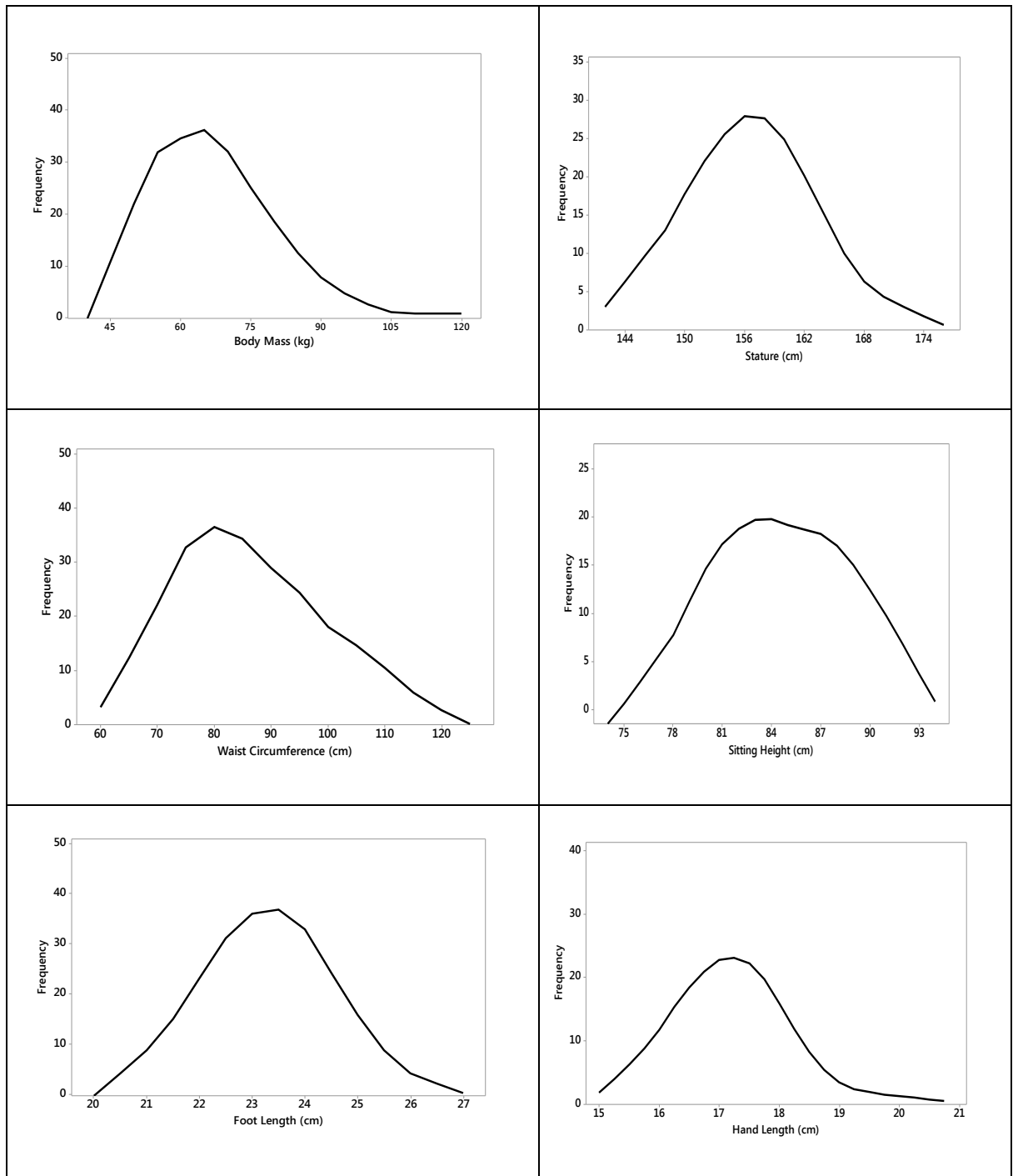


Figure 5.8. Distributions of some anthropometric measurements.

5.2. Inferential Statistics

In this section, significance of difference between erect and normal positions and linear correlations among measurements were tested.

5.2.1. Correlation Analysis

In Table 5.8 calculated Pearson Correlations are shown in order to see the linear relations between anthropometric characteristics.

- BMI is negatively and significantly correlated with some anthropometric measurements including most vertical measurements.
- There was a significant and positive correlation between BMI and some other anthropometric measurements such as chest depth and breadth, elbow-to-elbow breadth in both standing and sitting positions, thigh clearance, face breadth, hip breadth, shoulder bideltoid breadth, and some circumferences including chest, neck, waist, wrist and hand.
- Age was found significantly and negatively correlated with some anthropometric measurements including most standing postures including stature, eye height etc.
- There was a significant and positive correlation between age and some anthropometric measurements such as body mass, chest depth and breadth, standing and sitting elbow-to-elbow breadth, hip breadth and circumferences of neck, chest, waist, hand and wrist.
- There exists a high correlation among almost all vertical measurements and reaching positions.
- Stature does not have a correlation with chest depth and breadth, hip breadth, sitting elbow-to-elbow breadth, shoulder bideltoid breadth, and circumferences of neck, hand and wrist.

Table 5.7. Pearson Correlation coefficients between different anthropometric measurements.*

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13
2. Stature (e)	0,113 (0,074)												
3. Stature (n)	0,120 (0,059)	0,999 (<0,001)											
4. Eye ht (e)	0,122 (0,054)	0,978 (<0,001)	0,978 (<0,001)										
5. Eye ht (n)	0,124 (0,050)	0,979 (<0,001)	0,978 (<0,001)	0,998 (<0,001)									
6. Acr. (shld) ht (e)	0,196 (0,002)	0,942 (<0,001)	0,943 (<0,001)	0,961 (<0,001)	0,959 (<0,001)								
7. Acr. (shld) ht (n)	0,206 (0,001)	0,921 (<0,001)	0,922 (<0,001)	0,935 (<0,001)	0,935 (<0,001)	0,972 (<0,001)							
8. Elbow ht (n)	0,171 (0,007)	0,885 (<0,001)	0,885 (<0,001)	0,876 (<0,001)	0,875 (<0,001)	0,886 (<0,001)	0,870 (<0,001)						
9. Fngtip ht (n)	0,119 (0,059)	0,804 (<0,001)	0,805 (<0,001)	0,807 (<0,001)	0,802 (<0,001)	0,803 (<0,001)	0,796 (<0,001)						
10. Th-tip ht (n)	0,112 (0,077)	0,834 (<0,001)	0,835 (<0,001)	0,829 (<0,001)	0,827 (<0,001)	0,819 (<0,001)	0,811 (<0,001)	0,816 (<0,001)	0,937 (<0,001)				
11. Knuckle ht (n)	0,121 (0,056)	0,809 (<0,001)	0,810 (<0,001)	0,814 (<0,001)	0,811 (<0,001)	0,812 (<0,001)	0,806 (<0,001)	0,801 (<0,001)	0,919 (<0,001)	0,943 (<0,001)			
12. Waist ht (n)	-0,016 (0,806)	0,837 (<0,001)	0,839 (<0,001)	0,820 (<0,001)	0,824 (<0,001)	0,799 (<0,001)	0,751 (<0,001)	0,766 (<0,001)	0,605 (<0,001)	0,662 (<0,001)	0,624 (<0,001)		
13. Vertical grip rch	0,145 (0,022)	0,841 (<0,001)	0,841 (<0,001)	0,833 (<0,001)	0,832 (<0,001)	0,840 (<0,001)	0,765 (<0,001)	0,762 (<0,001)	0,609 (<0,001)	0,637 (<0,001)	0,607 (<0,001)	0,796 (<0,001)	
14. Vertical th-tip rch	0,146 (0,021)	0,846 (<0,001)	0,845 (<0,001)	0,841 (<0,001)	0,838 (<0,001)	0,849 (<0,001)	0,773 (<0,001)	0,772 (<0,001)	0,613 (<0,001)	0,636 (<0,001)	0,613 (<0,001)	0,798 (<0,001)	0,989 (<0,001)
15. Vertical fngtip rch	0,125 (0,049)	0,855 (<0,001)	0,853 (<0,001)	0,851 (<0,001)	0,849 (<0,001)	0,857 (<0,001)	0,780 (<0,001)	0,777 (<0,001)	0,623 (<0,001)	0,650 (<0,001)	0,629 (<0,001)	0,798 (<0,001)	0,982 (<0,001)
16. Forward grip rch	0,351 (<0,001)	0,576 (<0,001)	0,577 (<0,001)	0,591 (<0,001)	0,591 (<0,001)	0,628 (<0,001)	0,609 (<0,001)	0,518 (<0,001)	0,349 (<0,001)	0,367 (<0,001)	0,387 (<0,001)	0,477 (<0,001)	0,600 (<0,001)
17. Forward th-tip rch	0,354 (<0,001)	0,596 (<0,001)	0,597 (<0,001)	0,610 (<0,001)	0,607 (<0,001)	0,639 (<0,001)	0,619 (<0,001)	0,536 (<0,001)	0,376 (<0,001)	0,403 (<0,001)	0,419 (<0,001)	0,488 (<0,001)	0,615 (<0,001)
18. Forward fngtip rch	0,323 (<0,001)	0,625 (<0,001)	0,625 (<0,001)	0,633 (<0,001)	0,631 (<0,001)	0,648 (<0,001)	0,624 (<0,001)	0,557 (<0,001)	0,391 (<0,001)	0,413 (<0,001)	0,425 (<0,001)	0,495 (<0,001)	0,625 (<0,001)
19. Span	0,175 (0,005)	0,721 (<0,001)	0,721 (<0,001)	0,711 (<0,001)	0,711 (<0,001)	0,709 (<0,001)	0,623 (<0,001)	0,607 (<0,001)	0,418 (<0,001)	0,464 (<0,001)	0,473 (<0,001)	0,699 (<0,001)	0,777 (<0,001)
20. Elbow span	0,228 (<0,001)	0,645 (<0,001)	0,650 (<0,001)	0,641 (<0,001)	0,639 (<0,001)	0,625 (<0,001)	0,598 (<0,001)	0,607 (<0,001)	0,466 (<0,001)	0,482 (<0,001)	0,464 (<0,001)	0,561 (<0,001)	0,617 (<0,001)
21. Chest (bust) depth	0,814 (<0,001)	-0,088 (0,166)	-0,080 (0,205)	-0,073 (0,251)	-0,070 (0,269)	0,014 (0,825)	0,059 (0,356)	-0,018 (0,773)	-0,059 (0,352)	-0,066 (0,298)	-0,044 (0,493)	-0,175 (0,006)	-0,035 (0,582)
22. Chest (bust) brt	0,817 (<0,001)	-0,071 (0,265)	-0,065 (0,309)	-0,052 (0,411)	-0,051 (0,421)	0,031 (0,630)	0,076 (0,230)	0,007 (0,914)	-0,040 (0,524)	-0,042 (0,512)	-0,020 (0,755)	-0,198 (0,002)	-0,048 (0,449)
23. Stand. e-to-e brt	0,732 (<0,001)	-0,133 (0,035)	-0,126 (0,046)	-0,130 (0,039)	-0,126 (0,046)	-0,055 (0,386)	-0,035 (0,587)	-0,068 (0,284)	-0,152 (0,016)	-0,131 (0,038)	-0,106 (0,093)	-0,144 (0,023)	-0,068 (0,286)
24. Shld-elbow lgt	0,221 (<0,001)	0,529 (<0,001)	0,528 (<0,001)	0,578 (<0,001)	0,575 (<0,001)	0,648 (<0,001)	0,659 (<0,001)	0,409 (<0,001)	0,403 (<0,001)	0,399 (<0,001)	0,411 (<0,001)	0,380 (<0,001)	0,516 (<0,001)
25. Shld-fngtip lgt	0,225 (<0,001)	0,641 (<0,001)	0,643 (<0,001)	0,659 (<0,001)	0,664 (<0,001)	0,725 (<0,001)	0,771 (<0,001)	0,573 (<0,001)	0,255 (<0,001)	0,341 (<0,001)	0,352 (<0,001)	0,585 (<0,001)	0,628 (<0,001)
26. Shld-flst lgt	0,207 (0,001)	0,610 (<0,001)	0,612 (<0,001)	0,626 (<0,001)	0,626 (<0,001)	0,685 (<0,001)	0,754 (<0,001)	0,548 (<0,001)	0,325 (<0,001)	0,320 (<0,001)	0,260 (<0,001)	0,516 (<0,001)	0,554 (<0,001)
27. Foot lgt	0,293 (<0,001)	0,610 (<0,001)	0,614 (<0,001)	0,590 (<0,001)	0,592 (<0,001)	0,588 (<0,001)	0,576 (<0,001)	0,612 (<0,001)	0,454 (<0,001)	0,449 (<0,001)	0,470 (<0,001)	0,616 (<0,001)	0,543 (<0,001)
28. Foot brt	0,397 (<0,001)	0,231 (<0,001)	0,235 (<0,001)	0,203 (0,001)	0,207 (0,001)	0,201 (0,001)	0,224 (<0,001)	0,194 (0,002)	0,110 (0,082)	0,141 (0,026)	0,140 (0,027)	0,230 (<0,001)	0,211 (0,001)
29. Sit. ht(e)	0,172 (0,006)	0,815 (<0,001)	0,814 (<0,001)	0,800 (<0,001)	0,794 (<0,001)	0,761 (<0,001)	0,740 (<0,001)	0,743 (<0,001)	0,725 (<0,001)	0,769 (<0,001)	0,730 (<0,001)	0,641 (<0,001)	0,659 (<0,001)
30. Sit. ht (n)	0,163 (0,010)	0,812 (<0,001)	0,812 (<0,001)	0,795 (<0,001)	0,791 (<0,001)	0,761 (<0,001)	0,738 (<0,001)	0,735 (<0,001)	0,718 (<0,001)	0,762 (<0,001)	0,727 (<0,001)	0,647 (<0,001)	0,658 (<0,001)
31. Sit. eye ht (e)	0,209 (0,001)	0,768 (<0,001)	0,768 (<0,001)	0,783 (<0,001)	0,774 (<0,001)	0,756 (<0,001)	0,733 (<0,001)	0,713 (<0,001)	0,718 (<0,001)	0,726 (<0,001)	0,704 (<0,001)	0,589 (<0,001)	0,625 (<0,001)
32. Sit. eye ht (n)	0,209 (0,001)	0,772 (<0,001)	0,772 (<0,001)	0,785 (<0,001)	0,776 (<0,001)	0,756 (<0,001)	0,732 (<0,001)	0,716 (<0,001)	0,717 (<0,001)	0,728 (<0,001)	0,703 (<0,001)	0,602 (<0,001)	0,627 (<0,001)
33. Sit. acr. (shld) ht (e)	0,300 (<0,001)	0,634 (<0,001)	0,637 (<0,001)	0,657 (<0,001)	0,649 (<0,001)	0,714 (<0,001)	0,669 (<0,001)	0,647 (<0,001)	0,637 (<0,001)	0,646 (<0,001)	0,649 (<0,001)	0,516 (<0,001)	0,583 (<0,001)
34. Sit. acr. (shld) ht (n)	0,304 (<0,001)	0,638 (<0,001)	0,640 (<0,001)	0,658 (<0,001)	0,650 (<0,001)	0,715 (<0,001)	0,669 (<0,001)	0,657 (<0,001)	0,629 (<0,001)	0,644 (<0,001)	0,644 (<0,001)	0,537 (<0,001)	0,585 (<0,001)
35. Sit. elbow rest ht (n)	0,267 (<0,001)	0,249 (<0,001)	0,252 (<0,001)	0,278 (<0,001)	0,272 (<0,001)	0,298 (<0,001)	0,255 (<0,001)	0,341 (<0,001)	0,394 (<0,001)	0,406 (<0,001)	0,408 (<0,001)	0,178 (0,005)	0,235 (<0,001)
36. Knee ht	0,221 (<0,001)	0,761 (<0,001)	0,762 (<0,001)	0,736 (<0,001)	0,740 (<0,001)	0,735 (<0,001)	0,743 (<0,001)	0,697 (<0,001)	0,577 (<0,001)	0,593 (<0,001)	0,573 (<0,001)	0,677 (<0,001)	0,671 (<0,001)
37. Popliteal ht	-0,029 (0,652)	0,764 (<0,001)	0,763 (<0,001)	0,761 (<0,001)	0,763 (<0,001)	0,732 (<0,001)	0,725 (<0,001)	0,681 (<0,001)	0,623 (<0,001)	0,625 (<0,001)	0,649 (<0,001)	0,614 (<0,001)	0,638 (<0,001)
38. Buttock-knee lgt	0,372 (<0,001)	0,489 (<0,001)	0,488 (<0,001)	0,477 (<0,001)	0,480 (<0,001)	0,485 (<0,001)	0,443 (<0,001)	0,431 (<0,001)	0,322 (<0,001)	0,331 (<0,001)	0,324 (<0,001)	0,450 (<0,001)	0,554 (<0,001)
39. Buttock-popliteal lgt	0,339 (<0,001)	0,343 (<0,001)	0,345 (<0,001)	0,340 (<0,001)	0,349 (<0,001)	0,385 (<0,001)	0,393 (<0,001)	0,319 (<0,001)	0,174 (0,006)	0,229 (<0,001)	0,221 (<0,001)	0,343 (<0,001)	0,390 (<0,001)
40. Thigh clearance	0,668 (<0,001)	0,165 (0,009)	0,171 (0,007)	0,154 (0,015)	0,158 (0,012)	0,188 (0,003)	0,199 (0,002)	0,195 (0,002)	0,165 (0,009)	0,181 (0,004)	0,154 (0,015)	0,132 (0,037)	0,183 (0,004)
41. Buttock-Leg Lgt	0,264 (<0,001)	0,790 (<0,001)	0,790 (<0,001)	0,791 (<0,001)	0,790 (<0,001)	0,802 (<0,001)	0,804 (<0,001)	0,740 (<0,001)	0,658 (<0,001)	0,627 (<0,001)	0,628 (<0,001)	0,625 (<0,001)	0,693 (<0,001)
42. Sit.vertical grip rch	0,274 (<0,001)	0,742 (<0,001)	0,741 (<0,001)	0,755 (<0,001)	0,753 (<0,001)	0,770 (<0,001)	0,749 (<0,001)	0,712 (<0,001)	0,593 (<0,001)	0,625 (<0,001)	0,628 (<0,001)	0,640 (<0,001)	0,672 (<0,001)
43. Sit.vertical th-tip rch	0,267 (<0,001)	0,777 (<0,001)	0,778 (<0,001)	0,789 (<0,001)	0,788 (<0,001)	0,791 (<0,001)	0,774 (<0,001)	0,738 (<0,001)	0,625 (<0,001)	0,671 (<0,001)	0,653 (<0,001)	0,684 (<0,001)	0,695 (<0,001)
44. Sit.vertical fngtip rch	0,225 (<0,001)	0,760 (<0,001)	0,761 (<0,001)	0,769 (<0,001)	0,769 (<0,001)	0,767 (<0,001)	0,743 (<0,001)	0,726 (<0,001)	0,608 (<0,001)	0,644 (<0,001)	0,631 (<0,001)	0,675 (<0,001)	0,684 (<0,001)
45. Sit.forward grip rch	0,296 (<0,001)	0,557 (<0,001)	0,555 (<0,001)	0,562 (<0,001)	0,560 (<0,001)	0,592 (<0,001)	0,580 (<0,001)	0,500 (<0,001)	0,389 (<0,001)	0,382 (<0,001)	0,390 (<0,001)	0,444 (<0,001)	0,571 (<0,001)
46. Sit.forward th-tip rch	0,285 (<0,001)	0,585 (<0,001)	0,586 (<0,001)	0,585 (<0,001)	0,585 (<0,001)	0,617 (<0,001)	0,606 (<0,001)	0,534 (<0,001)	0,391 (<0,001)	0,403 (<0,001)	0,411 (<0,001)	0,473 (<0,001)	0,599 (<0,001)
47. Sit.forward fngtip rch	0,290 (<0,001)	0,605 (<0,001)	0,608 (<0,001)	0,604 (<0,001)	0,603 (<0,001)	0,625 (<0,001)	0,614 (<0,001)	0,545 (<0,001)	0,409 (<0,001)	0,421 (<0,001)	0,425 (<0,001)	0,498 (<0,001)	0,600 (<0,001)
48. Head circumf	0,316 (<0,001)	0,226 (<0,001)	0,228 (<0,001)	0,178 (0,005)	0,180 (0,004)	0,199 (0,002)	0,233 (<0,001)	0,204 (0,001)	0,114 (0,072)	0,162 (0,010)	0,156 (0,013)	0,181 (0,004)	0,184 (0,004)
49. Head lgt	0,210 (0,001)	0,242 (<0,001)	0,237 (<0,001)	0,212 (0,001)	0,211 (0,001)	0,212 (0,001)	0,235 (<0,001)	0,198 (0,002)	0,176 (0,005)	0,198 (0,002)	0,190 (0,003)	0,169 (0,007)	0,144 (0,023)
50. Head brt	0,225 (<0,001)	0,116 (0,068)	0,119 (0,061)	0,100 (0,116)	0,098 (0,122)	0,115 (0,071)	0,114 (0,072)	0,122 (0,054)	0,120 (0,057)	0,155 (0,014)	0,134 (0,035)	0,126 (0,047)	0,093 (0,144)
51. Ment-sellion (face) lgt	0,182 (0,004)	0,183 (0,004)	0,186 (0,003)	0,195 (0,002)	0,190 (0,003)	0,225 (<0,001)	0,213 (0,001)	0,207 (0,001)	0,131 (0,038)	0,146 (0,021)	0,153 (0,015)	0,190 (0,003)	0,206 (0,001)
52. Bizygomatic (face) brt	0,559 (<0,001)	0,106 (0,094)	0,117 (0,066)	0,082 (0,196)	0,090 (0,155)	0,135 (0,033)	0,180 (0,004)	0,154 (0,015)	0,043 (0,498)	0,084 (0,185)	0,063 (0,322)	0,072 (0,257)	0,074 (0,244)
53. Neck circumf	0,796 (<0,001)	0,034 (0,589)	0,044 (0,486)	0,038 (0,545)	0,042 (0,512)	0,109 (0,086)	0,130 (0,040)	0,059 (0,351)	0,054 (0,395)	0,071 (0,261)	0,073 (0,252)	-0,018 (0,773)	0,059 (0,350)
54. Chest circumf	0,874 (<0,001)	-0,121 (0,056)	-0,116 (0,067)	-0,102 (0,108)	-0,102 (0,109)	-0,006 (0,924)	0,038 (0,550)	-0,042 (0,509)	-0,0				

Table 5.7. Pearson Correlation coefficients between different anthropometric measurements (cont.).

Measurement	14	15	16	17	18	19	20	21	22	23	24	25	26
15. Vertical fngtip rch	0,992 (<0,001)												
16. Forward grip rch	0,601 (<0,001)	0,596 (<0,001)											
17. Forward th-tip rch	0,626 (<0,001)	0,619 (<0,001)	0,936 (<0,001)										
18. Forward fngtip rch	0,633 (<0,001)	0,633 (<0,001)	0,897 (<0,001)	0,930 (<0,001)									
19. Span	0,779 (<0,001)	0,786 (<0,001)	0,604 (<0,001)	0,620 (<0,001)	0,632 (<0,001)								
20. Elbow span	0,632 (<0,001)	0,633 (<0,001)	0,528 (<0,001)	0,575 (<0,001)	0,571 (<0,001)	0,648 (<0,001)							
21. Chest (bust) depth	-0,042 (0,508)	-0,069 (0,274)	0,238 (<0,001)	0,223 (<0,001)	0,156 (0,014)	0,011 (0,860)	0,115 (0,070)						
22. Chest (bust) brt	-0,045 (0,478)	-0,067 (0,290)	0,236 (<0,001)	0,224 (<0,001)	0,175 (0,005)	0,028 (0,655)	0,151 (0,017)	0,850 (<0,001)					
23. Stand. e-to-e brt	-0,072 (0,256)	-0,106 (0,093)	0,217 (0,001)	0,186 (0,003)	0,101 (0,110)	0,017 (0,785)	0,050 (0,431)	0,747 (<0,001)	0,772 (<0,001)				
24. Shld-elbow lgt	0,508 (<0,001)	0,514 (<0,001)	0,510 (<0,001)	0,485 (<0,001)	0,466 (<0,001)	0,438 (<0,001)	0,363 (<0,001)	0,180 (0,004)	0,181 (0,004)	0,076 (0,234)			
25. Shld-fngtip lgt	0,631 (<0,001)	0,631 (<0,001)	0,620 (<0,001)	0,604 (<0,001)	0,594 (<0,001)	0,599 (<0,001)	0,487 (<0,001)	0,190 (0,003)	0,194 (0,002)	0,135 (0,033)	0,663 (<0,001)		
26. Shld-flst lgt	0,558 (<0,001)	0,555 (<0,001)	0,565 (<0,001)	0,555 (<0,001)	0,563 (<0,001)	0,468 (<0,001)	0,453 (<0,001)	0,179 (0,005)	0,170 (0,007)	0,071 (0,264)	0,655 (<0,001)	0,871 (<0,001)	
27. Foot lgt	0,544 (<0,001)	0,545 (<0,001)	0,451 (<0,001)	0,453 (<0,001)	0,487 (<0,001)	0,532 (<0,001)	0,460 (<0,001)	0,130 (0,040)	0,106 (0,094)	0,072 (0,260)	0,299 (<0,001)	0,489 (<0,001)	0,454 (<0,001)
28. Foot brt	0,214 (0,001)	0,197 (0,002)	0,289 (<0,001)	0,268 (<0,001)	0,239 (<0,001)	0,264 (<0,001)	0,268 (<0,001)	0,339 (<0,001)	0,357 (<0,001)	0,107 (0,092)	0,297 (<0,001)	0,242 (<0,001)	
29. Sit. ht(e)	0,665 (<0,001)	0,677 (<0,001)	0,425 (<0,001)	0,436 (<0,001)	0,471 (<0,001)	0,561 (<0,001)	0,490 (<0,001)	-0,033 (0,602)	0,026 (0,680)	-0,070 (0,273)	0,391 (<0,001)	0,450 (<0,001)	0,433 (<0,001)
30. Sit. ht (n)	0,662 (<0,001)	0,673 (<0,001)	0,415 (<0,001)	0,424 (<0,001)	0,460 (<0,001)	0,560 (<0,001)	0,484 (<0,001)	-0,034 (0,596)	0,025 (0,696)	-0,059 (0,356)	0,399 (<0,001)	0,452 (<0,001)	0,430 (<0,001)
31. Sit. eye ht (e)	0,633 (<0,001)	0,643 (<0,001)	0,436 (<0,001)	0,448 (<0,001)	0,475 (<0,001)	0,532 (<0,001)	0,481 (<0,001)	0,016 (0,806)	0,076 (0,228)	-0,027 (0,671)	0,403 (<0,001)	0,452 (<0,001)	0,458 (<0,001)
32. Sit. eye ht (n)	0,635 (<0,001)	0,644 (<0,001)	0,435 (<0,001)	0,442 (<0,001)	0,465 (<0,001)	0,535 (<0,001)	0,482 (<0,001)	0,020 (0,750)	0,076 (0,231)	-0,019 (0,764)	0,394 (<0,001)	0,452 (<0,001)	0,455 (<0,001)
33. Sit. acr. (shld) ht (e)	0,590 (<0,001)	0,594 (<0,001)	0,402 (<0,001)	0,414 (<0,001)	0,397 (<0,001)	0,495 (<0,001)	0,418 (<0,001)	0,118 (0,063)	0,171 (0,007)	0,105 (0,096)	0,399 (<0,001)	0,424 (<0,001)	0,391 (<0,001)
34. Sit. acr. (shld) ht (n)	0,590 (<0,001)	0,592 (<0,001)	0,404 (<0,001)	0,416 (<0,001)	0,393 (<0,001)	0,503 (<0,001)	0,425 (<0,001)	0,126 (0,047)	0,177 (0,005)	0,132 (0,037)	0,388 (<0,001)	0,438 (<0,001)	0,397 (<0,001)
35. Sit. elbow rest ht (n)	0,238 (<0,001)	0,236 (<0,001)	0,101 (0,113)	0,111 (0,080)	0,123 (0,053)	0,085 (0,180)	0,159 (0,012)	0,126 (0,047)	0,138 (0,029)	0,137 (0,030)	0,100 (0,116)	0,006 (0,919)	-0,013 (0,844)
36. Knee ht	0,666 (<0,001)	0,675 (<0,001)	0,532 (<0,001)	0,543 (<0,001)	0,558 (<0,001)	0,592 (<0,001)	0,514 (<0,001)	0,077 (0,227)	0,053 (0,407)	0,027 (0,669)	0,458 (<0,001)	0,618 (<0,001)	0,610 (<0,001)
37. Popliteal ht	0,647 (<0,001)	0,662 (<0,001)	0,414 (<0,001)	0,455 (<0,001)	0,476 (<0,001)	0,562 (<0,001)	0,497 (<0,001)	-0,093 (0,142)	-0,109 (0,085)	-0,164 (0,009)	0,393 (<0,001)	0,543 (<0,001)	0,503 (<0,001)
38. Buttock-knee lgt	0,545 (<0,001)	0,532 (<0,001)	0,419 (<0,001)	0,382 (<0,001)	0,414 (<0,001)	0,515 (<0,001)	0,429 (<0,001)	0,209 (0,001)	0,210 (0,001)	0,220 (<0,001)	0,330 (<0,001)	0,392 (<0,001)	0,351 (<0,001)
39. Buttock-popliteal lgt	0,394 (<0,001)	0,372 (<0,001)	0,335 (<0,001)	0,331 (<0,001)	0,303 (<0,001)	0,361 (<0,001)	0,290 (<0,001)	0,306 (<0,001)	0,288 (<0,001)	0,312 (<0,001)	0,328 (<0,001)	0,478 (<0,001)	0,397 (<0,001)
40. Thigh clearance	0,183 (0,004)	0,156 (0,014)	0,239 (<0,001)	0,240 (<0,001)	0,223 (<0,001)	0,188 (0,003)	0,249 (<0,001)	0,584 (<0,001)	0,539 (<0,001)	0,500 (<0,001)	0,072 (0,260)	0,190 (0,003)	0,167 (0,008)
41. Buttock-Leg Lgt	0,694 (<0,001)	0,698 (<0,001)	0,633 (<0,001)	0,639 (<0,001)	0,645 (<0,001)	0,602 (<0,001)	0,581 (<0,001)	0,089 (0,158)	0,088 (0,163)	0,002 (0,969)	0,581 (<0,001)	0,614 (<0,001)	0,629 (<0,001)
42. Sit.vertical grip rch	0,691 (<0,001)	0,697 (<0,001)	0,520 (<0,001)	0,538 (<0,001)	0,538 (<0,001)	0,612 (<0,001)	0,561 (<0,001)	0,139 (0,028)	0,125 (0,049)	0,050 (0,428)	0,506 (<0,001)	0,601 (<0,001)	0,548 (<0,001)
43. Sit.vertical th-tip rch	0,712 (<0,001)	0,721 (<0,001)	0,514 (<0,001)	0,542 (<0,001)	0,551 (<0,001)	0,637 (<0,001)	0,594 (<0,001)	0,123 (0,053)	0,099 (0,117)	0,029 (0,652)	0,487 (<0,001)	0,610 (<0,001)	0,565 (<0,001)
44. Sit.vertical fngtip rch	0,696 (<0,001)	0,713 (<0,001)	0,477 (<0,001)	0,501 (<0,001)	0,520 (<0,001)	0,621 (<0,001)	0,566 (<0,001)	0,068 (0,286)	0,063 (0,320)	-0,015 (0,817)	0,469 (<0,001)	0,579 (<0,001)	0,540 (<0,001)
45. Sit.forward grip rch	0,567 (<0,001)	0,566 (<0,001)	0,766 (<0,001)	0,729 (<0,001)	0,713 (<0,001)	0,512 (<0,001)	0,414 (<0,001)	0,163 (0,010)	0,172 (0,006)	0,151 (0,017)	0,484 (<0,001)	0,532 (<0,001)	0,513 (<0,001)
46. Sit.forward th-tip rch	0,600 (<0,001)	0,596 (<0,001)	0,793 (<0,001)	0,779 (<0,001)	0,750 (<0,001)	0,569 (<0,001)	0,483 (<0,001)	0,155 (0,014)	0,150 (0,018)	0,147 (0,020)	0,452 (<0,001)	0,577 (<0,001)	0,538 (<0,001)
47. Sit.forward fngtip rch	0,600 (<0,001)	0,598 (<0,001)	0,784 (<0,001)	0,772 (<0,001)	0,778 (<0,001)	0,578 (<0,001)	0,484 (<0,001)	0,140 (0,027)	0,143 (0,024)	0,124 (0,049)	0,443 (<0,001)	0,572 (<0,001)	0,543 (<0,001)
48. Head circumf	0,177 (0,005)	0,181 (0,004)	0,253 (<0,001)	0,265 (<0,001)	0,247 (<0,001)	0,239 (<0,001)	0,269 (<0,001)	0,321 (<0,001)	0,299 (<0,001)	0,226 (<0,001)	0,224 (<0,001)	0,293 (<0,001)	0,251 (<0,001)
49. Head lgt	0,130 (0,039)	0,151 (0,017)	0,262 (<0,001)	0,276 (<0,001)	0,261 (<0,001)	0,214 (0,001)	0,219 (<0,001)	0,170 (0,007)	0,169 (0,007)	0,130 (0,040)	0,181 (0,004)	0,244 (<0,001)	0,233 (<0,001)
50. Head brt	0,107 (0,093)	0,108 (0,089)	0,191 (0,002)	0,208 (0,001)	0,187 (0,003)	0,152 (0,016)	0,230 (<0,001)	0,213 (0,001)	0,232 (<0,001)	0,184 (0,003)	0,139 (0,028)	0,084 (0,184)	0,081 (0,201)
51. Ment-sellion (face) lgt	0,204 (0,001)	0,199 (0,002)	0,214 (0,001)	0,231 (<0,001)	0,218 (0,001)	0,231 (<0,001)	0,157 (0,013)	0,149 (0,019)	0,161 (0,011)	0,127 (0,045)	0,197 (0,002)	0,226 (<0,001)	0,222 (<0,001)
52. Bizygomatic (face) brt	0,075 (0,237)	0,050 (0,435)	0,219 (<0,001)	0,227 (<0,001)	0,201 (0,001)	0,082 (0,196)	0,195 (0,002)	0,509 (<0,001)	0,517 (<0,001)	0,465 (<0,001)	0,136 (0,031)	0,274 (<0,001)	0,256 (<0,001)
53. Neck circumf	0,054 (0,394)	0,034 (0,593)	0,270 (<0,001)	0,248 (<0,001)	0,223 (<0,001)	0,111 (0,079)	0,130 (0,040)	0,755 (<0,001)	0,726 (<0,001)	0,727 (<0,001)	0,148 (0,020)	0,188 (0,003)	0,162 (0,010)
54. Chest circumf	-0,070 (0,269)	-0,092 (0,148)	0,225 (<0,001)	0,210 (0,001)	0,170 (0,007)	-0,013 (0,834)	0,075 (0,240)	0,887 (<0,001)	0,907 (<0,001)	0,760 (<0,001)	0,211 (0,001)	0,161 (0,011)	0,146 (0,021)
55. Waist circumf	-0,137 (0,030)	-0,167 (0,008)	0,182 (0,004)	0,153 (0,015)	0,094 (0,138)	-0,089 (0,160)	-0,008 (0,901)	0,845 (<0,001)	0,852 (<0,001)	0,786 (<0,001)	0,121 (0,056)	0,111 (0,080)	0,075 (0,237)
56. Hip brt (sit.)	0,023 (0,715)	0,007 (0,915)	0,170 (0,007)	0,152 (0,016)	0,129 (0,041)	0,078 (0,219)	0,126 (0,047)	0,711 (<0,001)	0,695 (<0,001)	0,625 (<0,001)	0,137 (0,031)	0,201 (0,001)	0,207 (0,001)
57. Sit. e-to-e brt (n)	-0,045 (0,483)	-0,072 (0,255)	0,237 (<0,001)	0,209 (0,001)	0,148 (0,019)	0,032 (0,617)	0,079 (0,212)	0,783 (<0,001)	0,782 (<0,001)	0,846 (<0,001)	0,123 (0,052)	0,193 (0,002)	0,137 (0,031)
58. Shld biacr. brt	0,238 (<0,001)	0,244 (<0,001)	0,202 (0,001)	0,253 (<0,001)	0,228 (<0,001)	0,300 (<0,001)	0,295 (<0,001)	0,220 (<0,001)	0,259 (<0,001)	0,208 (0,001)	0,130 (0,040)	0,283 (<0,001)	0,259 (<0,001)
59. Shld bideltoid brt	0,114 (0,073)	0,083 (0,191)	0,250 (<0,001)	0,245 (<0,001)	0,196 (0,002)	0,199 (0,002)	0,180 (0,004)	0,656 (<0,001)	0,684 (<0,001)	0,714 (<0,001)	0,049 (0,445)	0,135 (0,033)	0,055 (0,391)
60. Hand lgt	0,451 (<0,001)	0,451 (<0,001)	0,432 (<0,001)	0,442 (<0,001)	0,486 (<0,001)	0,508 (<0,001)	0,369 (<0,001)	0,149 (0,018)	0,147 (0,020)	0,114 (0,071)	0,316 (<0,001)	0,511 (<0,001)	0,474 (<0,001)
61. Hand brt	0,108 (0,089)	0,086 (0,176)	0,249 (<0,001)	0,252 (<0,001)	0,215 (0,001)	0,173 (0,006)	0,164 (0,009)	0,467 (<0,001)	0,490 (<0,001)	0,459 (<0,001)	0,214 (0,001)	0,322 (<0,001)	0,287 (<0,001)
62. Palm lgt perp	0,491 (<0,001)	0,470 (<0,001)	0,425 (<0,001)	0,384 (<0,001)	0,398 (<0,001)	0,524 (<0,001)	0,366 (<0,001)	0,212 (0,001)	0,212 (0,001)	0,217 (0,001)	0,283 (<0,001)	0,457 (<0,001)	0,384 (<0,001)
63. Index finger lgt	0,323 (<0,001)	0,349 (<0,001)	0,340 (<0,001)	0,373 (<0,001)	0,436 (<0,001)	0,317 (<0,001)	0,299 (<0,001)	0,027 (0,671)	0,056 (0,376)	-0,051 (0,423)	0,324 (<0,001)	0,369 (<0,001)	0,339 (<0,001)
64. Hand circumf	0,159 (0,012)	0,124 (0,050)	0,268 (<0,001)	0,277 (<0,001)	0,214 (0,001)	0,193 (0,002)	0,157 (0,013)	0,546 (<0,001)	0,582 (<0,001)	0,610 (<0,001)	0,243 (<0,001)	0,322 (<0,001)	0,248 (<0,001)
65. Wrist circumf	0,088 (0,164)	0,051 (0,426)	0,274 (<0,001)	0,279 (<0,001)	0,220 (<0,001)	0,130 (0,040)	0,160 (0,011)	0,662 (<0,001)	0,666 (<0,001)	0,713 (<0,001)	0,123 (0,052)	0,188 (0,003)	0,148 (0,019)

Table 5.7. Pearson Correlation coefficients between different anthropometric measurements (cont.).

Measurement	27	28	29	30	31	32	33	34	35	36	37	38	39
28. Foot brt	0,503 (<0,001)												
29. Sit. ht(e)	0,491 (<0,001)	0,265 (<0,001)											
30. Sit. ht (n)	0,483 (<0,001)	0,271 (<0,001)	0,986 (<0,001)										
31. Sit. eye ht (e)	0,488 (<0,001)	0,242 (<0,001)	0,915 (<0,001)	0,899 (<0,001)									
32. Sit. eye ht (n)	0,492 (<0,001)	0,251 (<0,001)	0,916 (<0,001)	0,901 (<0,001)	0,996 (<0,001)								
33. Sit. acr. (shld) ht (e)	0,425 (<0,001)	0,203 (0,001)	0,774 (<0,001)	0,765 (<0,001)	0,802 (<0,001)	0,797 (<0,001)							
34. Sit. acr. (shld) ht (n)	0,447 (<0,001)	0,234 (<0,001)	0,770 (<0,001)	0,763 (<0,001)	0,800 (<0,001)	0,799 (<0,001)	0,988 (<0,001)						
35. Sit. elbow rest ht (n)	0,209 (0,001)	0,119 (0,060)	0,485 (<0,001)	0,473 (<0,001)	0,483 (<0,001)	0,478 (<0,001)	0,582 (<0,001)	0,590 (<0,001)					
36. Knee ht	0,659 (<0,001)	0,340 (<0,001)	0,546 (<0,001)	0,537 (<0,001)	0,526 (<0,001)	0,537 (<0,001)	0,440 (<0,001)	0,450 (<0,001)	0,123 (0,052)				
37. Popliteal ht	0,522 (<0,001)	0,234 (<0,001)	0,585 (<0,001)	0,573 (<0,001)	0,584 (<0,001)	0,583 (<0,001)	0,480 (<0,001)	0,485 (<0,001)	0,169 (0,007)	0,637 (<0,001)			
38. Buttock-knee lgt	0,487 (<0,001)	0,292 (<0,001)	0,326 (<0,001)	0,330 (<0,001)	0,323 (<0,001)	0,328 (<0,001)	0,285 (<0,001)	0,306 (<0,001)	0,083 (0,191)	0,395 (<0,001)	0,313 (<0,001)		
39. Buttock-popliteal lgt	0,298 (<0,001)	0,260 (<0,001)	0,195 (0,002)	0,205 (0,001)	0,180 (0,004)	0,187 (0,003)	0,179 (0,005)	0,197 (0,002)	-0,007 (0,910)	0,370 (<0,001)	0,277 (<0,001)	0,532 (<0,001)	
40. Thigh clearance	0,343 (<0,001)	0,396 (<0,001)	0,190 (0,003)	0,180 (0,004)	0,219 (<0,001)	0,225 (<0,001)	0,218 (0,001)	0,236 (<0,001)	0,249 (<0,001)	0,321 (<0,001)	0,057 (0,371)	0,322 (<0,001)	0,334 (<0,001)
41. Buttock-Leg Lgt	0,567 (<0,001)	0,210 (0,001)	0,519 (<0,001)	0,512 (<0,001)	0,529 (<0,001)	0,522 (<0,001)	0,431 (<0,001)	0,429 (<0,001)	0,077 (0,225)	0,677 (<0,001)	0,604 (<0,001)	0,572 (<0,001)	0,441 (<0,001)
42. Sit.vertical grip rch	0,547 (<0,001)	0,245 (<0,001)	0,673 (<0,001)	0,664 (<0,001)	0,656 (<0,001)	0,659 (<0,001)	0,622 (<0,001)	0,626 (<0,001)	0,347 (<0,001)	0,582 (<0,001)	0,619 (<0,001)	0,362 (<0,001)	0,313 (<0,001)
43. Sit.vertical th-tip rch	0,558 (<0,001)	0,238 (<0,001)	0,695 (<0,001)	0,685 (<0,001)	0,670 (<0,001)	0,673 (<0,001)	0,622 (<0,001)	0,624 (<0,001)	0,331 (<0,001)	0,621 (<0,001)	0,645 (<0,001)	0,354 (<0,001)	0,310 (<0,001)
44. Sit.vertical fngtip rch	0,554 (<0,001)	0,200 (0,001)	0,690 (<0,001)	0,678 (<0,001)	0,661 (<0,001)	0,663 (<0,001)	0,615 (<0,001)	0,617 (<0,001)	0,337 (<0,001)	0,610 (<0,001)	0,625 (<0,001)	0,327 (<0,001)	0,270 (<0,001)
45. Sit.forward grip rch	0,381 (<0,001)	0,208 (0,001)	0,409 (<0,001)	0,401 (<0,001)	0,449 (<0,001)	0,437 (<0,001)	0,412 (<0,001)	0,412 (<0,001)	0,089 (0,160)	0,444 (<0,001)	0,386 (<0,001)	0,425 (<0,001)	0,312 (<0,001)
46. Sit.forward th-tip rch	0,416 (<0,001)	0,218 (0,001)	0,418 (<0,001)	0,406 (<0,001)	0,441 (<0,001)	0,440 (<0,001)	0,421 (<0,001)	0,431 (<0,001)	0,092 (0,145)	0,486 (<0,001)	0,441 (<0,001)	0,431 (<0,001)	0,357 (<0,001)
47. Sit.forward fngtip rch	0,473 (<0,001)	0,247 (<0,001)	0,466 (<0,001)	0,452 (<0,001)	0,480 (<0,001)	0,480 (<0,001)	0,435 (<0,001)	0,446 (<0,001)	0,126 (0,047)	0,504 (<0,001)	0,440 (<0,001)	0,434 (<0,001)	0,335 (<0,001)
48. Head circumf	0,368 (<0,001)	0,396 (<0,001)	0,247 (<0,001)	0,249 (<0,001)	0,192 (0,002)	0,195 (0,002)	0,218 (0,001)	0,235 (<0,001)	0,124 (0,050)	0,300 (<0,001)	0,205 (0,001)	0,217 (0,001)	0,237 (<0,001)
49. Head lgt	0,379 (<0,001)	0,411 (<0,001)	0,249 (<0,001)	0,249 (<0,001)	0,230 (<0,001)	0,224 (<0,001)	0,194 (0,002)	0,206 (0,001)	0,063 (0,321)	0,235 (<0,001)	0,250 (<0,001)	0,215 (0,001)	0,128 (0,044)
50. Head brt	0,252 (<0,001)	0,294 (<0,001)	0,165 (0,009)	0,165 (0,009)	0,145 (0,021)	0,152 (0,016)	0,123 (0,052)	0,133 (0,036)	0,151 (0,017)	0,157 (0,013)	0,094 (0,140)	0,191 (0,002)	0,182 (0,004)
51. Ment-sellion (face) lgt	0,270 (<0,001)	0,240 (<0,001)	0,179 (0,005)	0,165 (0,009)	0,200 (0,001)	0,197 (0,002)	0,251 (<0,001)	0,256 (<0,001)	0,108 (0,088)	0,208 (0,001)	0,217 (0,001)	0,214 (0,001)	0,185 (0,003)
52. Bizygomatic (face) brt	0,276 (<0,001)	0,421 (<0,001)	0,197 (0,002)	0,189 (0,003)	0,172 (0,006)	0,180 (0,004)	0,148 (0,019)	0,177 (0,005)	0,212 (0,001)	0,176 (0,005)	0,033 (0,603)	0,173 (0,006)	0,331 (<0,001)
53. Neck circumf	0,221 (<0,001)	0,442 (<0,001)	0,109 (0,086)	0,113 (0,075)	0,136 (0,031)	0,140 (0,027)	0,234 (<0,001)	0,250 (<0,001)	0,249 (<0,001)	0,170 (0,007)	-0,007 (0,916)	0,234 (<0,001)	0,320 (<0,001)
54. Chest circumf	0,090 (0,154)	0,308 (<0,001)	-0,027 (0,671)	-0,028 (0,654)	0,030 (0,633)	0,029 (0,651)	0,140 (0,027)	0,138 (0,029)	0,123 (0,053)	0,010 (0,877)	-0,174 (0,006)	0,192 (0,002)	0,272 (<0,001)
55. Waist circumf	0,036 (0,575)	0,280 (<0,001)	-0,142 (0,025)	-0,143 (0,024)	-0,106 (0,094)	-0,105 (0,096)	0,033 (0,601)	0,046 (0,469)	0,097 (0,125)	-0,046 (0,466)	-0,247 (<0,001)	0,162 (0,010)	0,286 (<0,001)
56. Hip brt (sit.)	0,254 (<0,001)	0,419 (<0,001)	0,127 (0,044)	0,117 (0,066)	0,150 (0,018)	0,161 (0,011)	0,157 (0,013)	0,176 (0,005)	0,186 (0,003)	0,251 (<0,001)	<0,001 (0,999)	0,289 (<0,001)	0,322 (<0,001)
57. Sit. e-to-e brt (n)	0,115 (0,070)	0,382 (<0,001)	-0,046 (0,465)	-0,040 (0,527)	-0,007 (0,915)	-0,004 (0,945)	0,056 (0,377)	0,076 (0,230)	0,063 (0,322)	0,088 (0,164)	-0,133 (0,035)	0,255 (<0,001)	0,315 (<0,001)
58. Shld biacr. brt	0,329 (<0,001)	0,433 (<0,001)	0,321 (<0,001)	0,299 (<0,001)	0,309 (<0,001)	0,320 (<0,001)	0,227 (<0,001)	0,226 (<0,001)	0,124 (0,050)	0,356 (<0,001)	0,377 (<0,001)	0,124 (0,051)	0,256 (<0,001)
59. Shld bideltoid brt	0,183 (0,004)	0,401 (<0,001)	0,089 (0,159)	0,092 (0,147)	0,100 (0,116)	0,111 (0,079)	0,186 (0,003)	0,199 (0,002)	0,176 (0,005)	0,101 (0,111)	-0,039 (0,536)	0,286 (<0,001)	0,330 (<0,001)
60. Hand lgt	0,507 (<0,001)	0,269 (<0,001)	0,392 (<0,001)	0,385 (<0,001)	0,352 (<0,001)	0,345 (<0,001)	0,353 (<0,001)	0,356 (<0,001)	0,080 (0,206)	0,485 (<0,001)	0,387 (<0,001)	0,343 (<0,001)	0,320 (<0,001)
61. Hand brt	0,304 (<0,001)	0,509 (<0,001)	0,159 (0,012)	0,158 (0,012)	0,180 (0,004)	0,173 (0,006)	0,235 (<0,001)	0,267 (<0,001)	0,178 (0,005)	0,186 (0,003)	0,183 (0,004)	0,177 (0,005)	0,283 (<0,001)
62. Palm lgt perp	0,537 (<0,001)	0,310 (<0,001)	0,333 (<0,001)	0,344 (<0,001)	0,336 (<0,001)	0,345 (<0,001)	0,353 (<0,001)	0,380 (<0,001)	0,121 (0,056)	0,459 (<0,001)	0,297 (<0,001)	0,429 (<0,001)	0,422 (<0,001)
63. Index finger lgt	0,379 (<0,001)	0,212 (0,001)	0,332 (<0,001)	0,306 (<0,001)	0,317 (<0,001)	0,295 (<0,001)	0,298 (<0,001)	0,279 (<0,001)	0,132 (0,037)	0,342 (<0,001)	0,328 (<0,001)	0,177 (0,005)	0,090 (0,157)
64. Hand circumf	0,254 (<0,001)	0,470 (<0,001)	0,139 (0,028)	0,159 (0,012)	0,152 (0,016)	0,148 (0,019)	0,299 (<0,001)	0,322 (<0,001)	0,196 (0,002)	0,147 (0,020)	0,042 (0,512)	0,222 (<0,001)	0,357 (<0,001)
65. Wrist circumf	0,306 (<0,001)	0,536 (<0,001)	0,140 (0,027)	0,144 (0,023)	0,164 (0,009)	0,169 (0,007)	0,275 (<0,001)	0,305 (<0,001)	0,248 (<0,001)	0,164 (0,009)	-0,011 (0,866)	0,270 (<0,001)	0,327 (<0,001)

Table 5.7. Pearson Correlation coefficients between different anthropometric measurements (cont.).

Measurement	40	41	42	43	44	45	46	47	48	49	50	51	52
41. Buttock-Leg Lgt	0,200 (0,002)												
42. Sit.vertical grip rch	0,303 (<0,001)	0,624 (<0,001)											
43. Sit.vertical th-tip rch	0,308 (<0,001)	0,633 (<0,001)	0,971 (<0,001)										
44. Sit.vertical fngtip rch	0,288 (<0,001)	0,601 (<0,001)	0,925 (<0,001)	0,949 (<0,001)									
45. Sit.forward grip rch	0,163 (0,010)	0,651 (<0,001)	0,473 (<0,001)	0,461 (<0,001)	0,438 (<0,001)								
46. Sit.forward th-tip rch	0,173 (0,006)	0,661 (<0,001)	0,499 (<0,001)	0,495 (<0,001)	0,459 (<0,001)	0,893 (<0,001)							
47. Sit.forward fngtip rch	0,189 (0,003)	0,656 (<0,001)	0,501 (<0,001)	0,499 (<0,001)	0,475 (<0,001)	0,856 (<0,001)	0,963 (<0,001)						
48. Head circumf	0,311 (<0,001)	0,179 (0,004)	0,281 (<0,001)	0,290 (<0,001)	0,281 (<0,001)	0,135 (0,033)	0,205 (0,001)	0,229 (<0,001)					
49. Head lgt	0,210 (0,001)	0,233 (<0,001)	0,236 (<0,001)	0,236 (<0,001)	0,226 (<0,001)	0,187 (0,003)	0,226 (<0,001)	0,233 (<0,001)	0,582 (<0,001)				
50. Head brt	0,286 (<0,001)	0,080 (0,205)	0,203 (0,001)	0,201 (0,001)	0,188 (0,003)	0,141 (0,026)	0,130 (0,040)	0,135 (0,033)	0,477 (<0,001)	0,262 (<0,001)			
51. Ment-sellion (face) lgt	0,186 (0,003)	0,218 (0,001)	0,299 (<0,001)	0,270 (<0,001)	0,228 (<0,001)	0,296 (<0,001)	0,246 (<0,001)	0,207 (0,001)	0,259 (<0,001)	0,212 (0,001)	0,330 (<0,001)		
52. Bizygomatic (face) brt	0,536 (<0,001)	0,068 (0,285)	0,240 (<0,001)	0,236 (<0,001)	0,195 (0,002)	0,168 (0,008)	0,190 (0,003)	0,203 (0,001)	0,433 (<0,001)	0,240 (<0,001)	0,473 (<0,001)	0,232 (<0,001)	
53. Neck circumf	0,578 (<0,001)	0,140 (0,027)	0,204 (0,001)	0,200 (0,002)	0,170 (0,007)	0,222 (<0,001)	0,196 (0,002)	0,184 (0,004)	0,275 (<0,001)	0,224 (<0,001)	0,283 (<0,001)	0,183 (0,004)	0,545 (<0,001)
54. Chest circumf	0,543 (<0,001)	0,079 (0,215)	0,099 (0,119)	0,075 (0,237)	0,035 (0,582)	0,188 (0,003)	0,151 (0,017)	0,139 (0,028)	0,286 (<0,001)	0,142 (0,025)	0,201 (0,001)	0,155 (0,014)	0,517 (<0,001)
55. Waist circumf	0,494 (<0,001)	-0,004 (0,954)	0,008 (0,905)	-0,031 (0,626)	-0,066 (0,298)	0,140 (0,027)	0,115 (0,069)	0,090 (0,156)	0,244 (<0,001)	0,117 (0,065)	0,168 (0,008)	0,096 (0,131)	0,500 (<0,001)
56. Hip brt (sit.)	0,654 (<0,001)	0,144 (0,023)	0,186 (0,003)	0,194 (0,002)	0,169 (0,007)	0,123 (0,052)	0,132 (0,037)	0,137 (0,031)	0,352 (<0,001)	0,260 (<0,001)	0,217 (0,001)	0,156 (0,014)	0,511 (<0,001)
57. Sit. e-to-e brt (n)	0,538 (<0,001)	0,085 (0,178)	0,050 (0,430)	0,042 (0,513)	-0,008 (0,898)	0,186 (0,003)	0,177 (0,005)	0,153 (0,015)	0,273 (<0,001)	0,205 (0,001)	0,192 (0,002)	0,110 (0,082)	0,541 (<0,001)
58. Shld biacr. brt	0,310 (<0,001)	0,189 (0,003)	0,385 (<0,001)	0,407 (<0,001)	0,371 (<0,001)	0,134 (0,035)	0,130 (0,041)	0,164 (0,009)	0,335 (<0,001)	0,298 (<0,001)	0,240 (<0,001)	0,186 (0,003)	0,325 (<0,001)
59. Shld bideltoid brt	0,545 (<0,001)	0,049 (0,437)	0,154 (0,015)	0,147 (0,020)	0,100 (0,115)	0,140 (0,027)	0,165 (0,009)	0,181 (0,004)	0,325 (<0,001)	0,179 (0,005)	0,300 (<0,001)	0,187 (0,003)	0,481 (<0,001)
60. Hand lgt	0,266 (<0,001)	0,434 (<0,001)	0,432 (<0,001)	0,455 (<0,001)	0,444 (<0,001)	0,385 (<0,001)	0,420 (<0,001)	0,443 (<0,001)	0,295 (<0,001)	0,212 (0,001)	0,119 (0,061)	0,222 (<0,001)	0,300 (<0,001)
61. Hand brt	0,420 (<0,001)	0,157 (0,013)	0,250 (<0,001)	0,239 (<0,001)	0,204 (0,001)	0,227 (<0,001)	0,239 (<0,001)	0,225 (<0,001)	0,331 (<0,001)	0,365 (<0,001)	0,304 (<0,001)	0,263 (<0,001)	0,519 (<0,001)
62. Palm lgt perp	0,376 (<0,001)	0,427 (<0,001)	0,353 (<0,001)	0,382 (<0,001)	0,363 (<0,001)	0,378 (<0,001)	0,401 (<0,001)	0,409 (<0,001)	0,234 (<0,001)	0,166 (0,008)	0,228 (<0,001)	0,232 (<0,001)	0,311 (<0,001)
63. Index finger lgt	0,109 (0,085)	0,417 (<0,001)	0,333 (<0,001)	0,346 (<0,001)	0,340 (<0,001)	0,346 (<0,001)	0,333 (<0,001)	0,355 (<0,001)	0,246 (<0,001)	0,310 (<0,001)	0,119 (0,059)	0,234 (<0,001)	0,114 (0,072)
64. Hand circumf	0,439 (<0,001)	0,130 (0,040)	0,193 (0,002)	0,178 (0,005)	0,149 (0,018)	0,277 (<0,001)	0,290 (<0,001)	0,256 (<0,001)	0,320 (<0,001)	0,193 (0,002)	0,302 (<0,001)	0,250 (<0,001)	0,549 (<0,001)
65. Wrist circumf	0,561 (<0,001)	0,116 (0,068)	0,192 (0,002)	0,176 (0,005)	0,126 (0,047)	0,252 (<0,001)	0,261 (<0,001)	0,249 (<0,001)	0,373 (<0,001)	0,304 (<0,001)	0,321 (<0,001)	0,311 (<0,001)	0,561 (<0,001)

Measurement	53	54	55	56	57	58	59	60	61	62	63	64
54. Chest circumf	0,757 (<0,001)											
55. Waist circumf	0,746 (<0,001)	0,903 (<0,001)										
56. Hip brt (sit.)	0,655 (<0,001)	0,704 (<0,001)	0,674 (<0,001)									
57. Sit. e-to-e brt (n)	0,699 (<0,001)	0,809 (<0,001)	0,798 (<0,001)	0,682 (<0,001)								
58. Shld biacr. brt	0,317 (<0,001)	0,202 (0,001)	0,155 (0,014)	0,359 (<0,001)	0,229 (<0,001)							
59. Shld bideltoid brt	0,629 (<0,001)	0,659 (<0,001)	0,638 (<0,001)	0,597 (<0,001)	0,685 (<0,001)	0,395 (<0,001)						
60. Hand lgt	0,218 (0,001)	0,140 (0,026)	0,114 (0,072)	0,226 (<0,001)	0,170 (0,007)	0,275 (<0,001)	0,181 (0,004)					
61. Hand brt	0,502 (<0,001)	0,421 (<0,001)	0,424 (<0,001)	0,466 (<0,001)	0,496 (<0,001)	0,286 (<0,001)	0,388 (<0,001)	0,328 (<0,001)				
62. Palm lgt perp	0,279 (<0,001)	0,179 (0,005)	0,198 (0,002)	0,265 (<0,001)	0,212 (0,001)	0,149 (0,019)	0,349 (<0,001)	0,528 (<0,001)	0,327 (<0,001)			
63. Index finger lgt	0,080 (0,210)	0,069 (0,278)	-0,008 (0,903)	0,115 (0,070)	0,011 (0,862)	0,188 (0,003)	-0,022 (0,733)	0,556 (<0,001)	0,278 (<0,001)	0,165 (0,009)		
64. Hand circumf	0,582 (<0,001)	0,570 (<0,001)	0,569 (<0,001)	0,476 (<0,001)	0,594 (<0,001)	0,221 (<0,001)	0,537 (<0,001)	0,317 (<0,001)	0,684 (<0,001)	0,440 (<0,001)	0,124 (0,051)	
65. Wrist circumf	0,698 (<0,001)	0,664 (<0,001)	0,658 (<0,001)	0,599 (<0,001)	0,710 (<0,001)	0,300 (<0,001)	0,600 (<0,001)	0,256 (<0,001)	0,589 (<0,001)	0,320 (<0,001)	0,169 (0,007)	0,719 (<0,001)

Table 5.8. Pearson correlation among anthropometric measurements, BMI and age.

Meas.	Body mass (kg)	Stature (e)	Stature (n)	Eye ht (e)	Eye ht (n)	Acr. (shld) ht (e)	Acr. (shld) ht (n)	Elbow ht (n)	Fngtip ht (n)	Th-tip ht (n)	Knuckle ht (n)	Waist ht (n)	Vertical grip rch
BMI	0,899 (p<0,001)	-0,306 (p<0,001)	-0,300 (p<0,001)	-0,289 (p<0,001)	-0,288 (p<0,001)	-0,205 (p=0,001)	-0,189 (p=0,003)	-0,203 (p=0,001)	-0,212 (p=0,001)	-0,236 (p<0,001)	-0,216 (p=0,001)	-0,374 (p<0,001)	-0,218 (p=0,001)
AGE	0,350 (p<0,001)	-0,350 (p<0,001)	-0,349 (p<0,001)	-0,340 (p<0,001)	-0,330 (p<0,001)	-0,246 (p<0,001)	-0,195 (p=0,002)	-0,232 (p<0,001)	-0,352 (p<0,001)	-0,339 (p<0,001)	-0,316 (p<0,001)	-0,307 (p<0,001)	-0,265 (p<0,001)

Meas.	Vertical th-tip rch	Vertical fngtip rch	Forward grip rch	Forward th-tip rch	Forward fngtip rch	Span	Elbow span	Chest (bust) depth	Chest (bust) brt	Stand. e-to-e brt	Shld-elbow lgt	Shld-fngtip lgt	Shld-fist lgt
BMI	-0,220 (p<0,001)	-0,243 (p<0,001)	0,099 (p=0,118)	0,089 (p=0,159)	0,050 (p=0,429)	-0,139 (p=0,028)	-0,052 (p=0,410)	0,812 (p<0,001)	0,804 (p<0,001)	0,745 (p<0,001)	-0,008 (p=0,901)	-0,063 (p=0,318)	-0,063 (p=0,322)
AGE	-0,274 (p<0,001)	-0,298 (p<0,001)	0,012 (p=0,844)	-0,042 (p=0,506)	-0,092 (p=0,148)	-0,220 (p<0,001)	-0,238 (p<0,001)	0,476 (p<0,001)	0,490 (p<0,001)	0,520 (p<0,001)	0,034 (p=0,593)	0,061 (p=0,335)	0,029 (p=0,647)

Meas.	Foot lgt	Foot brt	Sit. ht(e)	Sit. ht (n)	Sit. eye ht (e)	Sit. eye ht (n)	Sit. acr. (shld) ht (e)	Sit. acr. (shld) ht (n)	Sit. elbow rest ht (n)	Knee ht	Popliteal ht	Buttock-knee lgt	Buttock-popliteal lgt
BMI	0,021 (p=0,739)	0,289 (p<0,001)	-0,166 (p=0,008)	-0,173 (p=0,006)	-0,109 (p=0,087)	-0,110 (p=0,081)	0,019 (p=0,760)	0,021 (p=0,747)	0,152 (p=0,016)	-0,113 (p=0,075)	-0,339 (p<0,001)	0,151 (p=0,017)	0,171 (p=0,007)
AGE	-0,182 (p=0,004)	0,102 (p=0,107)	-0,343 (p<0,001)	-0,328 (p<0,001)	-0,312 (p<0,001)	-0,309 (p<0,001)	-0,151 (p=0,017)	-0,131 (p=0,039)	-0,133 (p=0,036)	-0,208 (p=0,001)	-0,314 (p<0,001)	-0,023 (p=0,721)	0,234 (p<0,001)

	Thigh clearance	Buttock-Leg Lgt	Sit.vertical grip rch	Sit.vertical th-tip rch	Sit.vertical fngtip rch	Sit.forward grip rch	Sit.forward th-tip rch	Sit.forward fngtip rch	Head circumf	Head lgt	Head brt	Ment-sellion (face) lgt	Bizygomatic (face) brt
BMI	0,558 (p<0,001)	-0,078 (p=0,222)	-0,052 (p=0,415)	-0,073 (p=0,253)	-0,105 (p=0,097)	0,053 (p=0,402)	0,030 (p=0,636)	0,026 (p=0,687)	0,216 (p=0,001)	0,111 (p=0,079)	0,175 (p=0,006)	0,095 (p=0,135)	0,483 (p<0,001)
AGE	0,100 (p=0,115)	-0,146 (p=0,021)	-0,162 (p=0,010)	-0,215 (p=0,001)	-0,238 (p<0,001)	0,040 (p=0,525)	0,012 (p=0,855)	-0,038 (p=0,548)	0,043 (p=0,494)	-0,032 (p=0,617)	0,003 (p=0,966)	0,068 (p=0,284)	0,244 (p<0,001)

Meas.	Neck circumf	Chest circumf	Waist circumf	Hip brt (sit.)	Sit. e-to-e brt (n)	Shld biacr. brt	Shld bideltoit brt	Hand lgt	Hand brt	Palm lgt perp	Index finger lgt	Hand circumf	Wrist circumf
BMI	0,743 (p<0,001)	0,882 (p<0,001)	0,859 (p<0,001)	0,716 (p<0,001)	0,758 (p<0,001)	0,147 (p=0,020)	0,686 (p<0,001)	0,042 (p=0,509)	0,370 (p<0,001)	0,098 (p=0,121)	0,010 (p=0,873)	0,503 (p<0,001)	0,661 (p<0,001)
AGE	0,403 (p<0,001)	0,514 (p<0,001)	0,604 (p<0,001)	0,314 (p<0,001)	0,492 (p<0,001)	-0,059 (p=0,352)	0,288 (p<0,001)	-0,057 (p=0,374)	0,320 (p<0,001)	0,050 (p=0,433)	-0,162 (p=0,010)	0,364 (p<0,001)	0,406 (p<0,001)

Table 5.9. Pearson correlation among some anthropometric measurements including body mass and habits/activities.

Meas.	Smoking habit (pocket/day)		Drinking habits (times/week)		Frequency of sportive activities (times/week)		Frequency of health control (times/year)	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Body Mass	-0.065	0.310	-0.193	0.002	0.116	0.067	0.142	0.024

Table 5.10 gives the correlation between body mass and smoking/drinking habits, frequency of sportive activities, and control on his health with each other. Results indicated that body mass is significantly and negatively correlated with drinking habit. Also, frequency of health control was found as a significant factor (positively correlated) with body mass. Although there is not significant correlation between body mass and smoking habit, the increase in the number of cigarette pockets per day results in the decrease in body mass value.

5.2.2. Paired T-Test Comparisons

Erect and normal anthropometric measurements have been tested by using paired t-test in order to check if mean differences of are significant. In the tests, the level of significance (α) was accepted as 0.05, and values between 0.05 and 0.1 were accepted as marginally significant.

$$H_0: \mu_{\text{difference}} = 0$$

$$H_1: \mu_{\text{difference}} > 0 \quad (5.2)$$

where $\mu_{\text{difference}} = \mu_{\text{erect}} - \mu_{\text{normal}}$ is the difference of the mean between two groups. Equations of paired t-test given in methods chapter were used for all measured dimensions in both erect and normal positions. This is shown in Table 5.7.

Table 5.10. Paired t-test table for eye ht and shoulder ht postures (erect vs. normal).

	$\bar{x}_{erect}$	$\bar{x}_{normal}$	$\bar{x}_{diff}$	s_{diff}	$t\ value$	$p\ value$	Significance Status
Stature	157,02	156,65	0,37	0,31	19,00	<0.01	Significant
Sitting height	85,47	84,69	0,78	0,67	18,53	<0.01	Significant
Eye height	146,51	145,74	0,77	0,38	31,78	<0.01	Significant
Eye height (sitting)	74,94	74,14	0,80	0,35	36,42	<0.01	Significant
Shoulder height	132	131,15	0,85	1,45	9,23	<0.01	Significant
Shoulder height (sitting)	60,61	59,53	1,08	0,54	31,61	<0.01	Significant

Table 5.7 indicates that, there are statistically significant differences between erect and normal positions for stature, sitting height, eye height and shoulder height (in both sitting and standing). In fact, calculated differences are practically very small. In other words, although statistical differences exist, there is no practical difference between normal and erect postures. This is maybe due to the high sample size. Since sample size is large, the null hypothesis is rejected at 99 significance level, although there is small practical difference between means (Montgomery, 2005).

5.2.3. Analysis of Variance

Initially, assumptions of ANOVA (analysis of variance) were checked to ensure applicability of this method. Then the method is applied for checking if factors age-group, job group or BMI group affect body dimensions.

a. Normality Assumption: This assumption was checked by making Anderson-Darling normality test ($\alpha=0.05$) in Minitab 17.0. For the residuals of body mass (kg), the result of the test was a p-value of 0.938. The null hypothesis, which states that data follows a normal distribution could not be rejected, since p-value was greater than 0.05. Another way of determining normality is checking the distribution of residuals. In figure 5.9, normal probability plot of residuals of body mass (kg) is shown. Residual points on the plot form almost a linear pattern, and fit the normal probability line, which indicates that the distribution is a good model for the body mass (kg) dataset.

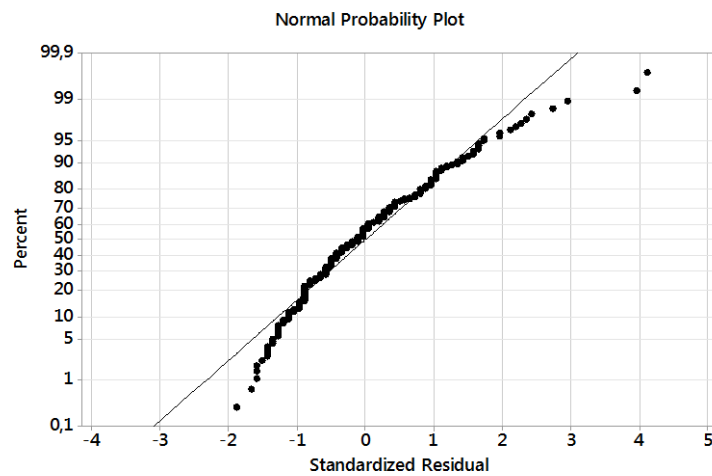


Figure 5.9. Normal probability plot for body mass (kg).

b. Independency Assumption: According to figure 5.10, residuals seems to distribute randomly around the residual=0 line. Therefore, it was concluded that residuals did not have a serial correlation. The assumption was satisfied.

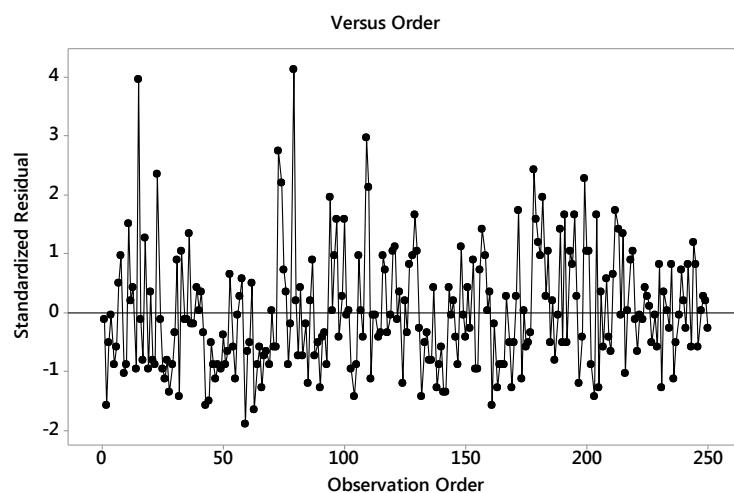


Figure 5.10. Plot of residuals versus observation order for subjects through body mass (kg).

c. Homogeneity assumption: This assumption is about the equality of variances of response variables across different groups. To check if there exists such equality, residuals of body mass (kg) vs. fitted values are plotted as in figure 5.11.

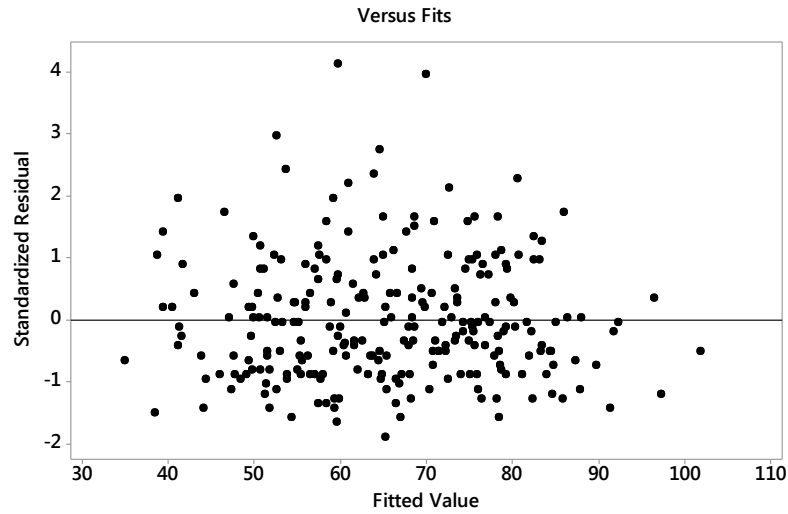


Figure 5.11. Equal variance probability plot for body mass (kg).

According to the plot, residuals seem to distribute randomly around the residual=0 line, and almost form a horizontal band around the line. Therefore variances across groups cannot be non-constant. Deduced randomness confirms the interpretation of independence assumption.

After checking the residual plot, another method for diagnosing the equality of variance could be applied when normality assumption is satisfied. (Montgomery, 2005) One method is Barlett's test of the hypotheses:

$$H_0: \sigma_1^2 = \sigma_2^2 \dots \sigma_n^2$$

$$H_1: \sigma_i^2 \neq \sigma_j^2 \text{ for at least one pair } (i,j)$$

where i and j stand for each distinct anthropometric measurement, and n=65 for this study. H_0 hypothesis states the equality of variances of anthropometric dimensions.

According to the results of Bartlett's test for stature (normal), test statistic is 10.71, and p-value is 0.296. Since this value is higher than 0.05, the null hypothesis cannot be rejected. This assumption was checked for all other measurements concluding that variances are the same for each treatment. The table of all results could be seen in the appendix section of the study.

According to the ANOVA results, there is no interaction effect. Thus, the statistical model used in this study can be stated as the following:

$$y_{ijk} = \mu + \alpha_i + \chi_j + \delta_k + \varepsilon_{ijk}$$

for $i = 1, 2, 3, 4, 5$ (1: 18-29 years)
 (2: 30-39 years)
 (3: 40-49 years)
 (4: 50-59 years)
 (5: 60-79 years)
 $j = 1, 2$ (1: Non-manual workers)
 (2: Manual workers)
 $k = 1, 2$ (1: Normal weight people)
 (2: Overweight people)

where,

y_{ijk} : ijk^{th} response (body dimension; e.g. body mass, stature)

μ : overall mean

α_i : effect of i^{th} level for age-group factor (1:18-29; 2: 30-39; 3:40-49; 4:50-59; 5:60-79)

χ_j : effect of j^{th} level for job-group factor (1:NM, 2:M)

δ_k : effect of k^{th} level for BMI-group factor (excluded underweight people) (1:Normal weight, 2:Over weight)

ε_{ijk} : NID $(0, \sigma^2)$ random error component

In tables below significant factors affecting body mass and stature in normal position are shown. Results in Table 5.11 indicate that BMI-group and age-group has a significant effect on body mass of subjects while job-group does not have any effect on it. Table 5.12 results show that age-group and BMI-group has a significant effect on stature while job-group does not significantly affect this dimension.

Table 5.11. Analysis of variance results for body mass of subjects.

Source	DF	Seq SS	Adj SS	Adj MS	F value	P value
Age-group	4	5823.2	978.2	244.5	2.65	<0.001
Job-group	1	0.5	40.8	40.8	0.44	0.507
Error	238	22300.6	22300.6	92.2		
Total	244	41997.2				

Table 5.12. Analysis of variance results for stature of subjects.

Source	DF	Seq SS	Adj SS	Adj MS	F value	P value
Age-group	4	1577.04	839.31	209.83	5.83	<0.001
Job-group	1	66.09	40.79	40.79	1.13	0.29
Error	238	8711.06	8711.06	36.00		
Total	244	10634.7				

For other anthropometric measurements, ANOVA results including p-values in Table 5.13 indicate the effects of factors including age-group, job-group, and BMI-group on the other anthropometric dimensions. Underweight people were excluded from the analysis the since there were only 5 people in BMI-group of underweight, and to conclude accurate results this is not a sufficient size.

Table 5.13. Summary of ANOVA results for other anthropometric measurements of subjects.*

Source	DF	Eye ht (n)	Acr. (shld) ht (n)	Elbow ht (n)	Fngtip ht (n)	Th-tip ht (n)	Fist ht (n)	Waist ht (n)
Age-group	4	5.56 (<0.001)	3.43 (0.010)	3.16 (0.015)	6.75 (0.000)	5.34 (<0.001)	5.29 (<0.001)	3.92 (0.004)
Job-group	1	2.05 (0.153)	0.03 (0.852)	0.04 (0.841)	0.51 (0.476)	0.23 (0.636)	0.02 (0.886)	5.97 (0.015)
BMI-group	1	4.97 (0.027)	1.83 (0.177)	3.53 (0.062)	1.52 (0.219)	3.20 (0.075)	1.81 (0.180)	8.40 (0.004)
Error	238							
Total	244							

* Numbers demonstrate F-value (p-value) in which the values in the first column indicates response values in the analysis of variance.

Source	DF	Vertical grip rch	Vertical th-tip rch	Vertical fngtip rch	Forward grip rch	Forward th-tip rch	Forward fngtip rch	Span	Elbow span
Age-group	4	5.97 (<0.001)	5.85 (<0.001)	6.24 (<0.001)	1.97 (0.099)	2.38 (0.052)	3.18 (0.014)	2.94 (0.021)	4.88 (0.001)
Job-group	1	2.67 (0.104)	2.64 (0.105)	2.73 (0.100)	0.00 (0.959)	0.03 (0.867)	0.60 (0.438)	2.88 (0.091)	0.02 (0.877)
BMI-group	1	0.30 (0.582)	0.39 (0.535)	0.88 (0.350)	2.89 (0.091)	4.93 (0.027)	3.80 (0.052)	0.72 (0.398)	0.13 (0.715)
Error	238								
Total	244								

Source	DF	Chest (bust) depth	Chest (bust) brt	Stand. e-to-e brt	Shld-elbow lgt	Shld-fngtip lgt	Shld-fist lgt	Foot lgt	Foot brt
Age-group	4	6.57 (<0.001)	6.84 (<0.001)	8.78 (<0.001)	4.25 (0.002)	1.62 (0.171)	2.21 (0.068)	3.98 (0.004)	1.11 (0.352)
Job-group	1	2.13 (0.146)	4.55 (0.034)	1.49 (0.224)	0.26 (0.611)	0.09 (0.768)	0.03 (0.857)	7.28 (0.007)	0.38 (0.537)
BMI-group	1	121.24 (<0.001)	101.99 (<0.001)	76.88 (<0.001)	0.39 (0.532)	0.35 (0.556)	0.04 (0.842)	3.47 (0.064)	8.96 (0.003)
Error	238								
Total	244								

Source	DF	Sit. ht (n)	Sit. eye ht (n)	Sit. acr. (shld) ht (n)	Sit. elbow rest ht (n)	Knee ht	Popliteal ht	Buttock-knee lgt	Buttock-popliteal lgt
Age-group	4	5.58 (<0.001)	4.94 (0.001)	1.21 (0.308)	2.56 (0.039)	3.77 (0.005)	5.42 (<0.001)	2.22 (0.067)	3.52 (0.008)
Job-group	1	0.21 (0.649)	0.34 (0.559)	0.14 (0.709)	0.95 (0.330)	3.54 (0.061)	0.14 (0.711)	6.55 (0.011)	0.02 (0.897)
BMI-group	1	0.59 (0.443)	0.00 (0.983)	0.89 (0.347)	4.94 (0.027)	0.32 (0.571)	4.69 (0.031)	4.19 (0.042)	2.43 (0.120)
Error	238								
Total	244								

Source	DF	Thigh clearance	Buttock-Leg Lgt	Sit.vertical grip rch	Sit.vertical th-tip rch	Sit.vertical fngtip rch	Sit.forward grip rch	Sit.forward th-tip rch	Sit.forward fngtip rch
Age-group	4	4.17 (0.003)	3.73 (0.006)	2.48 (0.044)	3.82 (0.005)	4.51 (0.002)	0.56 (0.695)	0.65 (0.627)	1.18 (0.322)
Job-group	1	0.26 (0.609)	1.76 (0.186)	0.86 (0.354)	0.97 (0.327)	0.92 (0.339)	0.00 (0.999)	0.31 (0.580)	0.07 (0.785)
BMI-group	1	66.61 (<0.001)	0.00 (0.992)	0.04 (0.846)	0.00 (0.960)	0.00 (0.975)	1.69 (0.195)	1.00 (0.319)	2.30 (0.131)
Error	238								
Total	244								

Table 5.13. Summary of ANOVA results for other anthropometric measurements of subjects.(cont.)

[illegible][illegible]

Results of ANOVA in Table 5.11, Table 5.12, and Table 5.13 could be interpreted as follows:

- Age-group significantly effects body mass.
- Age-group has a significant effect on stature.
- Age-group significantly affects all vertical anthropometric measurements, except sitting acromial shoulder height (n), shoulder fist length, shoulder fingertip length and many others.
- Age-group was found significant for almost all measurement related to face except menton-sellion (face) length.
- Age-group showed no significance on any dimension related to head.
- Age group has only a significant effect on forward fingertip reach among all dimensions related to forward reach, sitting and standing.
- Waist height, foot length, chest breadth, and waist circumference are affected by all three factors.
- Hand circumference and buttock-knee length are affected by job-groups and BMI-groups.
- Forward thumb-tip reach, foot breadth, head breadth, hip breadth, shoulder-biacromial breadth, and hand length are affected significantly only by BMI-groups.
- There is no factor affecting forward grip reach, shoulder-fingertip height, shoulder-fist height, sitting acromial (shoulder) height (n), sitting forward grip reach, sitting forward thumb-tip reach, sitting forward fingertip reach, and ment-sellion (face) length.
- There are significant effects of age-group and BMI-group on measurement of eye height (n), chest depth, standing elbow-to-elbow breadth, popliteal height, thigh clearance, bizygomatic (face) breadth, neck circumference, chest circumference, sitting elbow-to elbow breadth, hand breadth, wrist circumference.

5.2.4. Post-Hoc Analysis

In order to determine which group mean of a significant factor differs from the rest of means, Tukey's test was used. Although both erect and normal dimensions were measured in the study, Tukey's multiple comparison test was used only for the difference of means in normal dimensions, since people usually work in their normal positions rather than erect positions. Before applying to Tukey's test, Tables 5.11, 5.12 and 5.13 were utilized, since they provided information about the significance of the factor to be analyzed. Next, for the significant factor affecting regarding dimension, mean difference of the factor group is checked as in the following tables:

According to the results in Table 5.14, body mass is highest in age group (60-79) and lowest in age group (18-29); also, the difference between age-groups are significant. Job-group effect was not taken into account since it was concluded that this factor was not significant for body mass (kg) according to the results of Table 5.11.

Table 5.14. Tukey's test results for age-group differences in body mass.

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	6.77	(0.36)-(13.19)	2.35	0.032
(40-49)-(18-29)	5.66	(-0.89)-(12.21)	2.40	0.127
(50-59)-(18-29)	12.41	(5.93)-(18.89)	2.37	<0.001
(60-79)-(18-29)	12.96	(6.30)-(19.63)	2.44	<0.001
(40-49)-(30-39)	-1.11	(-7.75)-(5.53)	2.43	0.991
(50-59)-(30-39)	5.64	(-0.93)-(12.21)	2.41	0.132
(60-79)-(30-39)	6.19	(-0.56)-(12.95)	2.47	0.090
(50-59)-(40-49)	6.75	(0.04)-(13.45)	2.46	0.047
(60-79)-(40-49)	7.30	(0.42)-(14.18)	2.52	0.031
(60-79)-(50-59)	0.56	(-6.26)-(7.37)	2.50	0.999

For stature in normal position, once again only age-group was taken into account for Tukey's test since it had a significant effect according to the results of ANOVA in Table 5.12. Stature in normal position was found as highest in age group (18-29) and lowest in age group (60-79). The results of Tukey's test support this fact as given in Table 5.15.

Table 5.15. Tukey's test results for age-group differences in stature (n).

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.10	(-5.31)- (1.11)	1.18	0.381
(40-49)-(18-29)	-5.83	(-9.11)- (-2.55)	1.20	<0.001
(50-59)-(18-29)	-3.99	(-7.24)- (-0.75)	1.19	0.007
(60-79)-(18-29)	-6.94	(-10.27)- (-3.60)	1.22	<0.001
(40-49)-(30-39)	-3.73	(-7.05)- (-0.41)	1.22	0.019
(50-59)-(30-39)	-1.89	(-5.18)- (1.40)	1.20	0.517
(60-79)-(30-39)	-4.83	(-8.21)- (-1.45)	1.24	0.001
(50-59)-(40-49)	1.84	(-1.52)- (5.19)	1.23	0.565
(60-79)-(40-49)	-1.10	(-4.55)- (2.34)	1.26	0.906
(60-79)-(50-59)	-2.94	(-6.35)- (0.47)	1.25	0.128

Next, the following tables demonstrate Tukey's test results for some anthropometric measurements. For the results of other dimensions, the tables refer to Appendix part of this study.

Table 5.16. Tukey's test results for age-group differences in acromial shoulder height (n).

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.01	(-5.15)- (1.13)	1.15	0.404
(40-49)-(18-29)	-4.88	(-8.09)- (-1.68)	1.17	<0.001
(50-59)-(18-29)	-2.24	(-5.41)- (0.93)	1.16	0.300
(60-79)-(18-29)	-3.87	(-7.12)- (-0.61)	1.19	0.011
(40-49)-(30-39)	-2.88	(-6.12)- (0.37)	1.19	0.110
(50-59)-(30-39)	-0.23	(-3.45)- (2.98)	1.18	1.000
(60-79)-(30-39)	-1.86	(-5.16)- (1.45)	1.21	0.540
(50-59)-(40-49)	2.64	(-0.64)- (5.92)	1.20	0.180
(60-79)-(40-49)	1.02	(-2.34)- (4.38)	1.23	0.922
(60-79)-(50-59)	-1.62	(-4.95)- (1.71)	1.22	0.673

Table 5.17. Tukey's test results for age-group differences in vertical fingertip reach.

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.28	(-6.65)- (2.09)	1.60	0.611
(40-49)-(18-29)	-6.05	(-10.52)- (-1.59)	1.64	0.002
(50-59)-(18-29)	-3.28	(-7.69)- (1.14)	1.62	0.254
(60-79)-(18-29)	-8.97	(-13.51)- (-4.43)	1.66	<0.001
(40-49)-(30-39)	-3.77	(-8.29)- (0.75)	1.66	0.153
(50-59)-(30-39)	-0.99	(-5.47)- (3.48)	1.64	0.974
(60-79)-(30-39)	-6.68	(-11.29)- (-2.08)	1.69	0.001
(50-59)-(40-49)	2.78	(-1.79)- (7.34)	1.67	0.459
(60-79)-(40-49)	-2.91	(-7.60)- (1.77)	1.72	0.436
(60-79)-(50-59)	-5.69	(-10.33)- (-1.05)	1.70	0.007

Table 5.18. Tukey's test results for age-group differences in span.

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.95	(-4.70)- (2.81)	1.38	0.959
(40-49)-(18-29)	-3.42	(-7.25)- (0.42)	1.40	0.107
(50-59)-(18-29)	-1.81	(-5.60)- (1.98)	1.39	0.689
(60-79)-(18-29)	-5.31	(-9.21)- (-1.41)	1.43	0.002
(40-49)-(30-39)	-2.47	(-6.35)- (1.42)	1.42	0.413
(50-59)-(30-39)	-0.86	(-4.71)- (2.98)	1.41	0.973
(60-79)-(30-39)	-4.36	(-8.32)- (-0.41)	1.45	0.022
(50-59)-(40-49)	1.60	(-2.32)- (5.53)	1.44	0.798
(60-79)-(40-49)	-1.90	(-5.92)- (2.13)	1.48	0.700
(60-79)-(50-59)	-3.50	(-7.49)- (0.49)	1.46	0.116

Table 5.19. Tukey's test results for age-group differences in sit. height (normal).

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.14	(-2.17)- (1.90)	0.74	1.000
(40-49)-(18-29)	-2.10	(-4.17)- (-0.02)	0.76	0.046
(50-59)-(18-29)	-2.21	(-4.26)- (-0.16)	0.75	0.027
(60-79)-(18-29)	-3.53	(-5.64)- (-1.42)	0.77	<0.001
(40-49)-(30-39)	-1.96	(-4.06)- (0.14)	0.77	0.081
(50-59)-(30-39)	-2.08	(-4.16)- (0.00)	0.76	0.050
(60-79)-(30-39)	-3.40	(-5.53)- (-1.26)	0.78	<0.001
(50-59)-(40-49)	-0.12	(-2.24)- (2.00)	0.78	1.000
(60-79)-(40-49)	-1.44	(-3.61)- (0.74)	0.80	0.374
(60-79)-(50-59)	-1.32	(-3.48)- (0.84)	0.79	0.453

Table 5.20. Tukey's test results for BMI-group differences in popliteal height

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	-1.09	(-1.58)- (-0.60)	0.25	<0,001

Table 5.21. Tukey's test results for job-group differences in buttock-knee length

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	0.99	(0.19)- (1.78)	0.40	0.014

Table 5.22. Tukey's test results for BMI-group differences in buttock-knee length

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.53	(-0.30)- (1.35)	0.42	0.207

Table 5.23. Tukey's test results for age-group differences in chest circumference

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	4.66	(-0.44)- (9.77)	1.87	0.092
(40-49)-(18-29)	7.29	(2.08)- (12.50)	1.91	3.820
(50-59)-(18-29)	13.53	(8.37)- (18.68)	1.89	7.160
(60-79)-(18-29)	15.70	(10.4)- (21.00)	1.94	<0.001
(40-49)-(30-39)	2.62	(-2.66)- (7.90)	1.93	0.656
(50-59)-(30-39)	8.86	(3.64)- (14.09)	1.91	4.630
(60-79)-(30-39)	11.03	(5.66)- (16.41)	1.97	5.610
(50-59)-(40-49)	6.24	(0.91)- (11.57)	1.95	3.190
(60-79)-(40-49)	8.41	(2.94)- (13.89)	2.01	4.190
(60-79)-(50-59)	2.17	(-3.25)- (7.59)	1.99	0.810

Table 5.24. Tukey's test results for BMI-group differences in chest circumference

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	15.89	(13.81)- (17.96)	1.05	<0.001

Table 5.25. Tukey's test results for age-group differences in waist circumference.

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	6.61	(0.97)- (12.24)	2.06	0.012
(40-49)-(18-29)	8.44	(2.69)- (14.19)	2.11	0.001
(50-59)-(18-29)	16.83	(11.14)- (22.53)	2.09	<0.001
(60-79)-(18-29)	22.27	(16.41)- (28.12)	2.15	<0.001
(40-49)-(30-39)	1.83	(-4.00)- (7.66)	2.14	0.912
(50-59)-(30-39)	10.23	(4.46)- (16.00)	2.11	<0.001
(60-79)-(30-39)	15.66	(9.73)- (21.59)	2.17	<0.001
(50-59)-(40-49)	8.40	(2.51)- (14.28)	2.16	0.001
(60-79)-(40-49)	13.83	(7.79)- (19.87)	2.21	<0.001
(60-79)-(50-59)	5.43	(-0.55)- (11.42)	2.19	0.096

Table 5.26. Tukey's test results for job-group differences in waist circumference

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	-5.48	(-8.69)- (-2.26)	1.63	0.001

Table 5.27. Tukey's test results for BMI-group differences in waist circumference

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	18.60	(16.15)- (21.05)	1.24	<0.001

Table 5.28. Tukey's test results for BMI-group differences in hip brt (sit.)

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	4.29	(3.57)- (5.02)	0.37	<0.001

The interpretation of the results of Tukey's tests can be given as in the following:

- People at their 60s are the heaviest while those at their 20s are the lightest.
- People at their 20s are the tallest and have the bigger dimensions in almost all vertical measurements. These measurements decrease until 40s, then slightly increase at 50s and decrease again.
- Chest circumference increases with age, people at their 60s have largest chest circumference and people at their 20s have smallest values. Overweight people also have larger values in this dimension. This could be explained by the increasing weight with aging.
- For older ages, waist circumference is increasing, and people at their 60s have the largest values for the measurement of waist circumference.

5.2.5. Regression Analysis

In this section, prediction equations for body measurements were established for independent variables age, job group, body mass and stature.

5.2.5.1. Checking the Regression Assumptions. In the ANOVA section, it was checked if the assumptions of regression were fulfilled before applying the regression analysis. Some of those assumptions which were already checked for ANOVA were the same. The results showed that there were not significant violations of assumption; therefore the regression analysis was a valid technique to be used.

5.2.5.2. Regression Equation of Anthropometric Measurements. In this study, Minitab 17.0 was used in order to investigate type of relations between dimensions (response variables) and regressor variables. The result of this statistical analysis show that, there is no quadratic term in the regression model fitted, and all relations were found as linear.

In order to develop prediction equations, both correlation analysis and results of ANOVA were used for each measurement. Age, body mass and stature (n) were taken into consideration when applying regression. BMI-group was not used as a predictor in the model studies, since it is calculated by using body mass and stature in normal position. Instead, these two measurements themselves were used in the model, because it would violate independence assumption and would result in lower R_{adj}^2 values if BMI factor was used. In these models, quadratic terms and interaction effects between factors were found insignificant, so they were not included. Solely, main effects of factors were considered. While trying to maximize this value in regression equation, stepwise regression were used. Only main effects were taken into consideration when applying these methods. As an additional analysis, models including stature (normal) only as the independent variable were developed. In addition to selecting the model with a high R_{adj}^2 , Mallows' Cp statistics was also used. The precision and bias of the full model are compared to models with the best subsets of predictors with this statistics. If there are too many predictors in a model, this model can be relatively imprecise. On the other hand, a model with too few predictors can generate biased estimates. A model is considered as the best one when p value is

closest to the number of model parameters including the constant (Montgomery *et. al*, 2012).

Thus, the general form of the regression model is obtained given in the following equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \quad (5.5)$$

where

y : Response variable (e.g.; foot length, span, hand length, and so on)

β_0 : Constant

β_1 : Regression coefficient of age

β_2 : Regression coefficient of body mass

β_3 : Regression coefficient of stature in normal position

x_1 : Regressor variable of age

x_2 : Regressor variable of body mass

x_3 : Regressor variable of stature in normal position

ε : Error term ($\varepsilon \sim NID(0, \sigma^2)$)

Since p-values of the interaction effects between factors and quadratic terms were greater than the significance level of 0.05, those effects and terms were neglected. Therefore, the resultant models were in multiple linear regression form. Each independent variable in the equation is significant ($p < 0.05$). The regression equations of some anthropometric measurements including acromial (shoulder) height in standing posture, vertical fingertip reach, span, chest (bust) breadth, shoulder-fingertip length, foot length, sitting height (normal), buttock-leg length, head circumference, waist circumference, hand length and some others are given as follows:

Table 5.29. Regression analysis results of acromial (shoulder) height in standing posture

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	-14.50	3.79	-3.83	0.00		86.8 %
Age (yrs)	0.06	0.01	5.92	0.00	1.14	
Stature (cm)	0.91	0.02	39.62	0.00	1.14	

Table 5.30. Regression analysis results of vertical fingertip reach.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	16.50	6.97	2.36	0.02		72.7 %
Stature (cm)	1.15	0.04	25.79	0.00	1.00	

Table 5.31. Regression analysis results of span.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	28.00	7.69	3.64	0.00		52.4 %
Body Mass (kg)	0.05	0.02	2.05	0.04	1.02	
Stature (cm)	0.79	0.05	16.11	0.00	1.02	

Table 5.32. Regression analysis results of chest (bust) breadth.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	20.03	2.99	6.78	0.00		71.8 %
Age (yrs)	0.04	0.01	4.88	0.00	1.38	
Body Mass (kg)	0.19	0.01	20.35	0.00	1.23	
Stature (cm)	-0.04	0.02	-2.36	0.02	1.23	

Table 5.33. Regression analysis results of shoulder-fingertip length.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Age (yrs)	0.09	0.02	6.83	0.00	1.14	50.3 %
Stature (cm)	0.45	0.03	15.88	0.00	1.14	

Table 5.34. Regression analysis results of foot length.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	5.19	1.38	3.76	0.00		42.1 %
Body Mass (kg)	0.02	0.00	4.59	0.00	1.02	
Stature (cm)	0.11	0.01	12.08	0.00	1.02	

Table 5.35. Regression analysis results of sitting height (normal).

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	9.47	4.00	2.36	0.02		66.7 %
Age (yrs)	-0.03	0.01	-2.25	0.03	1.38	
Body Mass (kg)	0.03	0.01	2.59	0.01	1.23	
Stature (cm)	0.47	0.03	18.85	0.00	1.23	

Table 5.36. Regression analysis results of buttock-leg length.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Age (yrs)	0.03	0.01	1.98	0.04	1.38	65.4%
Body Mass (kg)	0.05	0.02	3.32	0.00	1.23	
Stature (cm)	0.58	0.03	19.42	0.00	1.24	

Table 5.37. Regression analysis results of head circumference.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	45.00	2.41	18.72	0.00		12.9 %
Body Mass (kg)	0.04	0.00	4.91	0.00	1.02	
Stature (cm)	0.05	0.02	3.24	0.00	1.02	

Table 5.38. Regression analysis results of waist circumference.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	91.1	9.91	9.19	0.00		80.7 %
Age (yrs)	0.24	0.03	8.32	0.00	1.38	
Body Mass (kg)	0.75	0.03	23.97	0.00	1.23	
Stature (cm)	-0.42	0.06	-6.74	0.00	1.23	

Table 5.39. Regression analysis results of hand length.

Predictor	Coefficient	SE Coefficient	T	P	VIF	R^2_{adj}
Constant	5.35	1.26	3.22	0.00		27.5 %
Body Mass (kg)	0.02	0.00	3.90	0.00	1.01	
Stature (cm)	0.07	0.01	8.48	0.00	1.02	

The existence of linear relationships between the response variables and a subset of independent variables was checked with a regression significance test (Montgomery, 2005). The appropriate hypotheses are,

$$H_0: \beta_1 = \beta_2 = \beta_3$$

$$H_1: \beta_j \neq 0 \text{ for at least one } j \quad (5.6)$$

At least one of the regressor variables contributes significantly to the model if Equation 5.6 is rejected. To test this significance, ANOVA approach is used.

The following tables indicate ANOVA results of regression models for some anthropometric measurements. According to the results, at least one of the regressor variables contribute significantly to the model ($p < 0.05$).

Table 5.40. Analysis of variance table of regression model for acromial (shoulder) height (normal) in standing posture.

Source	DF	SS	MS	F	P
Regression	2	8138.90	4069.50	820.74	<0.001
Residual Error	247	1224.70	4.90		
Total	249	9363.60			

Table 5.41. Analysis of variance table of regression model for vertical fingertip reach.

Source	DF	SS	MS	F	P
Regression	1	13957.00	13957.00	665.07	<0.001
Residual Error	248	5205.00	21.10		
Total	249	19162.01			

Table 5.42. Analysis of variance table of regression model for span.

Source	DF	SS	MS	F	P
Regression	4	7017.70	1754.40	68.97	<0.001
Residual Error	245	6232.10	25.40		
Total	249	13249.90			

Table 5.43. Analysis of variance table of regression model for chest (bust) breadth.

Source	DF	SS	MS	F	P
Regression	3	1937.51	645.84	212.41	<0.001
Residual Error	246	747.98	3,04		
Total	249	2685.48			

Table 5.44. Analysis of variance table of regression model for shoulder-fingertip length

Source	DF	SS	MS	F	P
Regression	2	1929.61	964.81	127.03	<0.001
Residual Error	247	1875.99	7.60		
Total	249	3805.60			

Table 5.45. Analysis of variance table of regression model for foot length.

Source	DF	SS	MS	F	P
Regression	2	149.94	74.97	91.54	<0.001
Residual Error	247	202.29	0.82		
Total	249	352.23			

Table 5.46. Analysis of variance table of regression model for sitting height (normal).

Source	DF	SS	MS	F	P
Regression	3	2730.25	910.08	166.97	<0.001
Residual Error	246	1340.86	5.45		
Total	249	4071.12			

Table 5.47. Analysis of variance table of regression model for buttock-leg length.

Source	DF	SS	MS	F	P
Regression	3	3655.91	1218.60	157.98	<0.001
Residual Error	246	1897.62	7.74		
Total	249	5553.50			

Table 5.48. Analysis of variance table of regression model for head circumference.

Source	DF	SS	MS	F	P
Regression	2	96.95	48.47	19.52	<0.001
Residual Error	247	613.36	2.48		
Total	249	710.31			

Table 5.49. Analysis of variance table of regression model for waist circumference.

Source	DF	SS	MS	F	P
Regression	3	34967.00	11656.30	348.61	<0.001
Residual Error	246	8225.20	33.10		
Total	249	43191.40			

Table 5.50. Analysis of variance table of regression model for hand length.

Source	DF	SS	MS	F	P
Regression	2	66.36	33.18	48.19	<0.001
Residual Error	247	170.08	0.69		
Total	249	236.44			

Variance inflation factors (VIF) shows the extent to which a regression coefficient will be affected because of the variable's redundancy with other independent variables. Namely, the degrees to which predictors that are correlated with other predictors (multicollinearity) are present in a regression analysis. It may not be problematic if

moderate multicollinearity exists. However, severe multicollinearity is a problem since it increases the variance of the regression coefficients, therefore they become unstable and difficult to interpret. The amount of inflation of the variance of the estimated regression coefficients is measured with Variance Inflation factors (VIF) as compared to when the predictor variables are not linearly correlated. The case of $VIF = 1$ means that predictors are not correlated. If $1 < VIF < 5$, it means that predictors are moderately correlated. If $5 < VIF < 10$, predictors are highly correlated. VIF values greater than 10 may indicate serious multicollinearity (O'Brien, 2007). In order to prevent multicollinearity, only VIF values less than 5 were taken into consideration in this study. Reducing multicollinearity is possible when variables, which are highly correlated to each other's are removed from the model, since they supply unnecessary information. In Tables 5.51, the results of stepwise methods for regression equations with variables including age, body mass and stature that provide maximum R^2_{adj} are shown. Moreover, another table of regression models, which maximize R^2_{adj} value for more measurements, is given in appendix B.2. Table 5.52 demonstrates regression models taking only stature as explanatory variable for each anthropometric measurement.

Table 5.51. Regression equations with the independent variables including age, body mass and stature for some dimensions. *

Anthropometric Variable (Response)	Regression Model	SE	R^2_{adj}	C_p
Acromial (shoulder) height (n)	$y = -14.5 + 0.06x \text{ Age} + 0.91x \text{ Stature}$	2.23	86.8 %	4.0
Vertical fingertip reach	$y = 16.5 + 1.15x \text{ Stature}$	4.58	72.7 %	0.6
Span	$y = 28.0 + 0.05x \text{ Body Mass} + 0.79x \text{ Stature}$	5.03	52.4 %	2.0
Chest (bust) breadth	$y = 20.3 + 0.04x \text{ Age} + 0.19x \text{ Body Mass} - 0.04x \text{ Stature}$	1.74	71.8 %	4.0
Shoulder-fingertip length	$y = -3.02 + 0.09x \text{ Age} + 0.45x \text{ Stature}$	2.76	50.3 %	2.3
Foot length	$y = 5.19 + 0.02x \text{ Body Mass} + 0.11x \text{ Stature}$	0.90	42.1 %	3.8
Sitting height (normal)	$y = 9.47 - 0.02x \text{ Age} + 0.03x \text{ Body Mass} + 0.47x \text{ Stature}$	2.33	66.7 %	4.0
Buttock-leg length	$y = -1.07 + 0.03x \text{ Age} + 0.05x \text{ Body Mass} + 0.58x \text{ Stature}$	2.77	65.4 %	4.0
Head circumference	$y = 45.0 + 0.04x \text{ Body Mass} + 0.05x \text{ Stature}$	1.58	12.9 %	2.0
Waist circumference	$y = 91.1 + 0.24x \text{ Age} + 0.75x \text{ Body Mass} - 0.42x \text{ Stature}$	5.78	80.7 %	4.0
Hand length	$y = 5.35 + 0.02x \text{ Body Mass} + 0.07x \text{ Stature}$	0.83	27.5 %	2.4

*All responses (in cm), age (in years), body mass (in kg) and stature (in cm) SE shows standard error of the model; R^2_{adj} shows percentage of response variable variation.

Table 5.51. Regression equations with the independent variables including age, body mass and stature for some dimensions (cont.).

Anthropometric Variable (Response)	Regression Model (y as response)	SE	R²_{adj}	C_p
Eye height (n)	$y = -10.2 + 1.00 \times \text{Stature}$	1.38	95.7 %	0.9
Elbow height	$y = -15.5 + 0.03 \times \text{Age} + 0.71 \times \text{Stature}$	2.31	78.9 %	3.4
Fingertip height	$y = -12.5 - 0.02 \times \text{Age} + 0.47 \times \text{Stature}$	2.31	65.0 %	4.0
Thumb-tip height	$y = -12.0 + 0.49 \times \text{Stature}$	2.13	69.5 %	3.1
Fist (grip axis, knuckle) height	$y = -10.2 + 0.51 \times \text{Stature}$	2.42	65.4 %	2.3
Waist height	$y = -14.7 - 0.05 \times \text{Body Mass} + 0.69 \times \text{Stature}$	2.80	71.6 %	3.3
Vertical grip reach	$y = 13.4 + 1.10 \times \text{Stature}$	4.64	70.6 %	1.8
Vertical thumb-tip reach	$y = 15.4 + 1.12 \times \text{Stature}$	4.63	71.4 %	1.8
Forward grip reach	$y = 14.8 + 0.03 \times \text{Age} + 0.06 \times \text{Body Mass} + 0.29 \times \text{Stature}$	2.37	42.1 %	4.0
Forward thumb-tip reach	$y = 16.0 + 0.08 \times \text{Body Mass} + 0.31 \times \text{Stature}$	2.67	43.3 %	3.8
Forward fingertip reach	$y = 16.3 + 0.07 \times \text{Body Mass} + 0.34 \times \text{Stature}$	2.79	44.9 %	2.5

Table 5.52. Regression equations with stature for some anthropometric measurements.*

Anthropometric Variable (Response)	Regression Model (y as response)	SE	R^2_{adj}
Body mass	$y = 29.20 + 0.24xStature$	12.92	1.00 %
Eye height	$y = -10.20 + 1.00xStature$	1.38	95.70 %
Shoulder height	$y = -4.43 + 0.87xStature$	2.37	85.00 %
Elbow height	$y = -10.50 + 0.68xStature$	2.35	78.30 %
Fingertip height	$y = -16.10 + 0.48xStature$	2.33	64.60 %
Thumb-tip height	$y = -12.00 + 0.49xStature$	2.13	69.50 %
Fist Height	$y = -10.20 + 0.51xStature$	2.42	65.40 %
Waist height	$y = -16.10 + 0.67xStature$	2.86	70.30 %
Vertical grip reach	$y = 13.40 + 1.10xStature$	4.64	70.60 %
Vertical thumb-tip reach	$y = 15.40 + 1.12xStature$	4.63	71.40 %
Vertical fingertip reach	$y = 16.50 + 1.15xStature$	4.58	72.70 %
Forward grip reach	$y = 21.40 + 0.28xStature$	2.55	33.00 %
Forward thumb-tip reach	$y = 18.20 + 0.32xStature$	2.85	35.40 %
Forward fingertip reach	$y = 18.40 + 0.36xStature$	2.94	38.80 %
Span	$y = 29.40 + 0.80xStature$	5.07	51.70 %
Elbow span	$y = -6.91 + 0.55xStature$	4.24	42.00 %
Chest (bust) depth	$y = 32.80 - 0.04xStature$	3.51	0.20 %
Chest (bust) breadth	$y = 33.10 - 0.03xStature$	3.28	0.00 %
Standing elbow-to-elbow breadth	$y = 62.90 - 0.11xStature$	5.56	1.20 %
Shoulder-elbow length	$y = 2.75 + 0.20xStature$	2.12	27.60 %
Shoulder-fingertip length	$y = 11.40 + 0.39xStature$	3.00	41.20 %
Shoulder-grip axis length	$y = -0.47 + 0.40xStature$	3.34	37.20 %
Foot length	$y = 5.79 + 0.11xStature$	0.94	37.40 %
Foot breadth	$y = 5.52 + 0.02xStature$	0.61	5.10 %
Sitting height	$y = 5.98 + 0.50xStature$	2.36	65.80 %
Sitting eye height	$y = 1.78 + 0.46xStature$	2.49	59.50 %
Sitting acromial (shoulder) ht	$y = 5.67 + 0.34xStature$	2.70	40.70 %
Sitting elbow rest height	$y = 6.46 + 0.12xStature$	3.12	6.00 %
Knee height	$y = 1.45 + 0.29xStature$	1.63	57.90 %
Popliteal height	$y = 1.87 + 0.23xStature$	1.28	58.10 %
Buttock-knee length	$y = 17.90 + 0.24xStature$	2.81	23.50 %
Buttock-popliteal length	$y = 25.40 + 0.14xStature$	2.41	11.50 %
Thigh clearance	$y = 7.38 + 0.04xStature$	1.51	2.50 %
Buttock-leg length	$y = 5.04 + 0.57xStature$	2.90	62.20 %
Sitting vertical grip reach	$y = 25.00 + 0.58xStature$	3.44	54.80 %
Sitting vertical thumb-tip reach	$y = 21.20 + 0.63xStature$	3.33	60.40 %
Sitting vertical fingertip reach	$y = 29.40 + 0.61xStature$	3.41	57.80 %
Sitting forward grip reach	$y = 20.40 + 0.29xStature$	2.82	30.60 %
Sitting forward thumb-tip reach	$y = 19.10 + 0.32xStature$	2.91	34.10 %
Sitting forward fingertip reach	$y = 19.70 + 0.35xStature$	3.03	36.70 %
Head circumference	$y = 46.20 + 0.06xStature$	1.65	4.80 %
Head length	$y = 13.00 + 0.03xStature$	0.83	5.20 %
Head breadth	$y = 13.00 + 0.01xStature$	0.73	1.00 %
Menton-sellion (face) length	$y = 8.07 + 0.02xStature$	0.83	3.10 %
Bizygomatic (face) breadth	$y = 10.80 + 0.01xStature$	0.67	1.00 %
Neck Circumference	$y = 31.10 + 0.02xStature$	2.23	<0.01 %
Chest Circumference	$y = 128.00 - 0.20xStature$	11.14	0.90 %
Waist Circumference	$y = 154.00 - 0.43xStature$	12.89	4.20 %
Hip breadth	$y = 33.80 + 0.03xStature$	3.52	<0.01 %
Sitting elbow-to-elbow breadth	$y = 55.30 - 0.06xStature$	5.31	0.20 %
Shoulder biacromial breadth	$y = 16.10 + 0.12xStature$	2.47	9.00 %
Shoulder bideltoid breadth	$y = 40.80 + 0.00xStature$	3.37	<0.01 %
Hand length	$y = 5.81 + 0.07xStature$	0.85	23.30 %
Hand breadth	$y = 6.27 + 0.01xStature$	0.51	1.60 %
Palm length perpendicular	$y = 2.68 + 0.04xStature$	0.56	20.60 %
Index finger length	$y = 2.38 + 0.03xStature$	0.48	13.50 %
Hand circumference	$y = 17.00 + 0.02xStature$	1.17	0.40 %
Wrist circumference	$y = 14.80 + 0.01xStature$	1.22	<0.01 %

*All responses (in cm) except body mass (in kg) and stature (in cm) SE shows standard error of the model; R^2_{adj} shows percentage of response variable variation.

Table 5.51 and Table 5.52 can be interpreted as below;

- Nearly all vertical dimensions are highly correlated with stature, since models which take those measurements as response variable provide high values of R^2_{adj} .
- Almost all dimensions of breadth, depth and circumference have either a very weak correlation with stature, or have no correlation at all, since models including those measurements have either a R^2_{adj} value very close to 0, or a value of 0 itself.

6. DISCUSSION

6.1. Discussion on the Results

In general, the results of this study are consistent with a number of studies in the literature. The discussions of the results are stated in the following sections.

6.1.1. Age Effect

Correlation analysis shows that age is significantly and negatively correlated with almost all length and vertical measurements. ANOVA results also indicate the same. This could be related with shrinking of the spine with ageing and/or secular trend. However, body mass, depth, breadth and circumference measurements including chest depth, chest breadth, hip breadth, face breadth, waist circumference, neck circumference, wrist circumference values increase with age. This may be attributed to the alterations of total or regional fat distribution and increased BMI with ageing.

6.1.2. Job Effect

On average non-manual workers are about 2 cm taller than manual workers while standing. In sitting height, the difference is negligible. However, ANOVA results show that job group does not affect most of the measurements in the study. Figure 5.4 and 5.5 indicate that manual workers are shorter than manual workers, in both sitting and standing height (normal). However, the differences are not significant due to the ANOVA results in Table 5.13. Moreover, Table 5.3 shows that, nonmanual workers are found lighter than the manual workers are, however this result is not also significant as seen in Table B.3 in Appendix B.2. Results indicate that, Non-manual group have significantly narrower waist circumference, according to Table 5.26 and significantly narwover chest breadth according to Table B.25 in Appendix B.2. There is no significant difference on average body mass of subjects in terms of job-group.

6.1.3. BMI Effect

The correlation between BMI and age is 0.47 with a p value < 0.001 . The positive correlation indicates that obesity increases with aging. One explanation is the decrease in metabolic rate with inactivity due to aging.

6.1.4. Other Effects

As statistical analysis provided in this study suggests, frequency of sportive activities has no significant effect on body mass. Also, there is a positive but weak correlation between the frequency of health controls and body mass.

6.2. Comparison with Previous Studies

6.2.1. Comparison with Previous Studies of Other Nationalities

In the literature there is not a single study that considered all 65 measurements that are included in this study. So the comparisons are made with matching dimensions. In addition, age-group, job-group and BMI-group are also not considered at once in the studies examined.

In Table 6.1, the information of some anthropometric studies that were compared with the current study are summarized. Also, mean and standard deviation values for stature and body mass for each age-group were given.

There are different age-groups in each study in Table 6.1; and also, measurement values are different for the same age-group for different nations. By this context, it is important to determine age ranges and compare studies in the same conditions.

Table 6.1. Stature and body mass values of adult females for some nationalities.

Source	Country	Age-group	Stature (cm)	Body Mass (kg)
			$\bar{x}(s)$	$\bar{x}(s)$
Present Study (2016)	Turkey	Overall (18-79 yrs)	157.02 (6.62)	66.50 (12.99)
		18-29 yrs	160.67 (6.82)	59.19 (11.22)
		30-39 yrs	158.55 (4.99)	65.96 (13.88)
		40-49 yrs	154.81 (6.17)	64.85 (10.88)
		50-59 yrs	156.58 (6.14)	71.60 (11.97)
		60-79 yrs	153.63 (6.67)	72.16 (12.81)
Mebarki & Davies (1990)	Algeria	16-25 yrs	159.20 (5.20)	56.00 (8.32)
		26-35 yrs	157.70 (5.97)	59.90 (11.40)
		36-45 yrs	156.40 (4.30)	61.90 (15.60)
		45-65 yrs	157.00 (4.98)	73.10 (17.20)
Bolstad et al. (2001)	Norway	Overall (20-39 yrs)	166.30 (6.10)	63.00 (9.30)
		20-29 yrs	166.00 (6.10)	63.90 (9.30)
		30-39 yrs		
Santos et al. (2004)	Chile and South America	60-64 yrs	151.20 (6.00)	67.80 (13.50)
		65-69 yrs	151.00 (5.80)	66.80 (14.00)
		70-74 yrs	150.10 (6.10)	64.10 (11.60)
		75-80 yrs	149.40 (6.50)	62.00 (12.40)
		80-84 yrs	147.70 (6.00)	58.50 (11.60)
		85-99 yrs	145.70 (6.80)	53.10 (10.70)
Barroso et al. (2005)	Portugal	17-65 yrs	156.5 (6.60)	64.00 (1.00)
Jinky Leilanie Del Prado-Leon (2007)	Philippines	Overall	153.92 (8.28)	N/A
Duan et al. (2007)	China	65-69 yrs	154.40 (6.00)	N/A
		70-74 yrs	152.10 (6.00)	
		>75 yrs	149.90 (8.70)	
Klamklay et al. (2008)	Thailand	18-25 yrs	156.90 (4.85)	49.84 (7.50)
Datta et al. (2008)	India	18-60 yrs	153.25 (5.50)	48.1 (4.38)
Coqueiro et al. (2009)	Cuba	60-64 yrs	155.00 (7.00)	64.95 (13.84)
		65-69 yrs	154.00 (7.00)	62.97 (14.81)
		70-74 yrs	153.00 (7.00)	59.19 (12.30)
		75-80 yrs	152.00 (6.00)	56.72 (12.51)
		>80 yrs	15<0.01 (7.00)	53.19 (11.56)
Hanson et al.(2009)	Sweden	18-65 yrs	166.30 (6.60)	65.00 (9.00)

Table 6.1. Stature and body mass values of adult females for some nationalities (cont.).

Source	Country	Age-group	Stature (cm)	Body Mass (kg)
			$\bar{x}(s)$	$\bar{x}(s)$
Chuan <i>et al.</i> (2010)	Indonesia Singapore	18-45 yrs	159.00 (5.76)	53.00 (11.68)
		18-45 yrs	162.00 (4.23)	53.00 (5.42)
Daruis <i>et al.</i> (2010)	Malaysia	18-40 yrs	156.37 (6.36)	52.22 (11.71)
Fryar <i>et al.</i> (2012)	U.S.A	Overall (20+ yrs)	162.1 (0.14)	75.4 (0.35)
		20-29 yrs	163.1 (0.24)	73.4 (1.13)
		30-39 yrs	163.4 (0.29)	76.7 (0.94)
		40-49 yrs	163.1 (0.22)	76.2 (0.74)
		50-59 yrs	163.2 (0.30)	77.1 (0.83)
		60-69 yrs	161.6 (0.26)	77.4 (0.65)
		70-79 yrs	159.1 (0.32)	74.8 (0.69)
		80+ yrs	155.9 (0.36)	64.9 (0.73)
Grasgruber & Hrazdira (2012)	Czech Republic	18-29 yrs	168.80 (6.70)	N/A
Alrashdan <i>et al.</i> (2014)	Saudi Arabia	18-25 yrs	160.34 (6.33)	57.60 (10.71)
Syuaib (2015)	Indonesia	18-46 yrs	152.5 (4.4)	52.3 (7.7)

Bolstad *et al.* (2001) conducted a study to measure anthropometric characteristics from a sample of 119 female adults from Norway population, ages 20 to 39 through 2 age groups. In order to compare with this study, to be accurate the groups of 20-39 in Bolstad's study was compared with the group of 20-39 years and manual job group in this study in which there were 38 subjects. In the study of Bolstad, stature values in erect position for 20-39 years are 166.10 ± 6.10 cm and body mass values for those are 63.40 ± 9.30 kg. Moreover, in the present study, stature values in erect position for 20-29 and 30-39 years are 157.72 ± 6.38 cm and 158.06 ± 4.85 cm, and body mass values for those are 63.12 ± 8.58 kg and 69.05 ± 16.90 kg.

Table 6.2. Comparison of results of Bolstad *et al.* (2001) with the current study.

Study	Stature (cm)	Body Mass (kg)
Bolstad <i>et al.</i> (2001) for 20-39 years	166.10 (6.10)	63.40 (9.30)
Present Study for 20-39 years, manual	157.90 (5.51)	66.39 (13.97)
Difference	8.20	2.99
T-value	7.77	1.24
P-value	<0.01	0.22
Significance	Significant	Not significant

In Table 6.2, the results of t-test to compare the anthropometric measurement values of Norwegian population studied by Bolstad *et al.* (2001) and the current study can be seen. Results show that there is significant difference between stature values in these populations; however, no significant difference between body mass values through such age groups.

In the study conducted by Barroso *et al.* (2005) 399 adult female Portuguese industrial workers aged from 17 to 65 years old could be compared with 115 subjects with ages ranging from 18 to 65 years old manual workers in current study. Table 6.3 shows the differences. The 4.70 kg difference in body mass values of these populations is statistically significant.

Table 6.3. Comparison of results of Barroso *et al.* (2005) with the current study.

Study	Stature (cm)	Body Mass (kg)
Barroso <i>et al.</i> (2005) for 17-65 years	156.80 (6.60)	64.00 (1.00)
Present Study for 18-65 years, manual	155.37 (6.51)	68.70 (12.58)
Difference	1.43	4.70
T-value	2.07	4.00
P-value	0.04	<0.01
Significance	Not Significant	Significant

Table 6.4. Comparison of results of Coqueiro *et al.* (2009) with the current study.

Study	Stature (cm)	Body Mass (kg)
Coqueiro <i>et al.</i> (2009) for 60-80 years	152.80 (6.80)	59.40 (13.00)
Present Study for 60-79 years	153.65 (6.67)	72.16 (12.81)
Difference	0.85	12.76
T-value	1.80	3.06
P-value	0.07	<0.01
Significance	Not Significant	Significant

Table 6.4 demonstrates the differences in stature and body mass between Coqueiro *et al.* (2009) and the current study. Coqueiro *et al.* conducted a study to measure anthropometric characteristics from a sample of 1197 elderly women in Cuba, ≥ 60 years of age. It can be compared with 60-79 years of age group in this study in which there is 45 women. According to the results of this comparison, there is no a significant difference between stature of elderly women from Cuba and elderly female population of Turkey; however there is significant difference between body mass values of these populations.

As another study, Table 6.5 indicates Datta *et al.* (2008) studied on Indian female farm workers through age between 18-60 years and 400 subjects were measured. In order to compare this study with the present study, it was taken into consideration 18-59 years as an age-group, and manual workers as job group and there are a total of 102 women in this age range. According to the results, the differences between anthropometric measurements including stature and body mass were significantly different between Indian and Turkish adults since p-value is smaller than level of significance, 0.05. On the other hand, according to the results, representative subjects in population of Turkey are higher and thinner than Indian representatives.

Table 6.5. Comparison of results of Datta *et al.* (2008) with the current study.

Study	Stature (cm)	Body Mass (kg)
Datta <i>et al.</i> (2008) for 18-60 years	153.25 (5.50)	48.10 (4.38)
Present Study for 18-59 years and manual	156.17 (5.81)	66.82 (12.85)
Difference	2.92	18.72
T-value	5.07	16.43
P-value	<0.01	<0.01
Significance	Significant	Significant

Table 6.6. Comparison of results of Santos *et al.* (2004) with the current study.

Study	Stature (cm)	Body Mass (kg)
Santos <i>et al.</i> (2004) for 60-80 years	150.43 (6.10)	65.18 (12.88)
Present Study for 60-79 years	153.65 (6.67)	72.16 (12.81)
Difference	3.22	6.98
T-value	7.14	7.51
P-value	<0.01	<0.01
Significance	Significant	Significant

Table 6.6 indicates Santos *et al.* (2004) studied on elderly Chilean people through age ranges between 60-99 years and 809 subjects were measured. In order to compare this study with the present study, it was taken into consideration 60-79 years as an aged-group, and there are a total of 45 men in this age range. According to the results, the differences between anthropometric measurements including stature and body mass were significantly different between Chilean and Turkish adults since p-value is smaller than level of significance, 0.05. On the other hand, according to the results, representative subjects in population of Turkey are higher and heavier than Chilean representatives.

In table 6.7 the differences between the current study and Fryar *et al.* (2012) are presented. Fryar *et al.* (2012), collected 10 anthropometric measurements from 11,495 survey participants representing U.S population, with ages 20 years old and greater. Comparison is made for 5,844 female subjects in the survey and 247 subjects with 20+ years age in this study. Table 6.7 shows that differences both stature and body mass are significant.

Table 6.7. Comparison of results of Fryar *et al.* (2012) with the current study.

Study	Stature (cm)	Body Mass (kg)
Fryar <i>et al.</i> (2012) for 20-79 years	162.10 (0.14)	75.40 (0.35)
Present Study for 20-79 years	156.58 (6.55)	66.60 (13.02)
Difference	5.52	8.80
T-value	13.25	10.62
P-value	<0.01	<0.01
Significance	Significant	Significant

Next, Table 6.8 shows the results of comparison present study with the studies for female farm workers from North Eastern India, Singaporean and Indonesian female population, and Sweden female population. According to the results, there is a significant difference in 34 measurements between Indian and Turkish population of manual workers while the differences in other measurements are not significant. In general, Indian population in Datta's study is shorter and thinner than Turkish female population of manual workers.

According to the results given in Table 6.8, with respect to the comparison between the female population of Sweden and Turkey, there is no significant difference in shoulder elbow length, foot breadth, head circumference, head length, head breadth, hand length and hand breadth. However, for all other dimensions including body mass, stature, waist height, foot length, knee height, and hip breadth differ significantly from each other for the females of the populations of Sweden and Turkey. It can be concluded that, Turkish females are heavier, but shorter in vertical dimensions than Swedish females.

Another comparison could be made between Indonesian and Singaporean females, 18-45 years, and Turkish female between 18-49 years. In order to do this, for each matching measurement, mean and standard deviation values are combined for present

study. According to the results, only the differences between 5 measurements are not significant. Those measurements are foot breadth, sitting height, sitting eye height, sitting vertical grip reach, and head length. All other measurements are significantly different, namely Singaporean and Indonesian females are thinner and taller than Turkish female population.

Table 6.8. Comparison of results of present study with the studies for some other nations.

Anthropometric Measurement	Present Study (2016) for manuel workers 18-60 yrs	Datta et al. (2008) for 18-60 years	p-value (Datta et al. vs Present)	Present Study (2016) for 18-65 yrs	Hanson et al. (2009) for 18-65 yrs	p-value (Hanson et al. vs Present)	Present Study (2016) for 18-49 yrs	Chuan et al. (2010) for 18-45 years	p-value (Chuan et al. vs Present)
Body mass (kg)	68.7 (12.77)	48.01 (4.38)	<0.01	65.73 (12.91)	64.00 (1.10)	<0.01	63.21 (12.00)	53.00 (5.42)	<0.01
Stature (e)	155.72 (6.69)	N/A	N/A	157.58 (6.50)	N/A	N/A	158.14 (6.01)	N/A	N/A
Stature (n)	155.38 (6.6)	153.25 (5.50)	<0.01	157.20 (6.40)	167.30 (6.80)	<0.01	157.75 (5.94)	162.00 (4.23)	<0.01
Eye height (e)	145.26 (6.74)	N/A	N/A	147.09 (6.61)	N/A	N/A	147.58 (6.16)	N/A	N/A
Eye height (n)	144.5 (6.7)	141.76 (5.16)	<0.01	146.3 (6.55)	155.30 (6.6)	<0.01	146.76 (6.12)	150.00 (5.41)	<0.01
Acr. (shld) ht (e)	131.16 (6.01)	N/A	N/A	132.29 (5.76)	N/A	N/A	132.51 (5.46)	N/A	N/A
Acr. (shld) ht (n)	130.52 (6.55)	127.09 (4.27)	<0.01	131.37 (5.93)	135.70 (6.30)	<0.01	131.46 (5.44)	134.00 (3.83)	<0.01
Elbow height (n)	95.64 (5.08)	96.18 (4.22)	0.38	96.61 (5.01)	104.40 (5.20)	<0.01	96.84 (5.07)	102.00 (3.5)	<0.01
Fingertip height (n)	58.71 (3.65)	N/A	N/A	59.70 (3.85)	N/A	N/A	60.01 (3.65)	62.00 (2.57)	<0.01
Thumb-tip height (n)	64.72 (3.73)	N/A	N/A	65.55 (3.74)	N/A	N/A	65.84 (3.55)	N/A	N/A
Fist(gr.ax,knck)ht (n)	69.29 (3.86)	N/A	N/A	70.15 (3.96)	N/A	N/A	70.43 (3.79)	71.00 (2.49)	<0.01
Waist height (n)	88.45 (5.4)	89.54 (3.94)	0.96	89.97 (5.07)	93.04 (5.20)	<0.01	90.49 (4.84)	N/A	N/A
Vertical grip rch	184.5 (9.11)	184.38 (6.41)	0.01	186.59 (7.88)	N/A	N/A	186.95 (7.53)	189.00 (14.7)	<0.01
Vertical th-tip rch	189.23 (9.16)	N/A	N/A	191.37 (8)	N/A	N/A	191.79 (7.72)	N/A	N/A
Vertical fngtip rch	194.32 (9.21)	N/A	N/A	196.67 (8.14)	N/A	N/A	197.2 (7.81)	N/A	N/A
Forward grip rch	64.37 (3.16)	N/A	N/A	64.51 (2.90)	N/A	N/A	64.3 (2.74)	68.00 (2.88)	<0.01
Forward th-tip rch	68.89 (3.69)	68.68 (3.18)	0.25	69.05 (3.41)	N/A	N/A	68.9 (3.36)	N/A	N/A
Forward fngtip rch	74.5 (3.7)	N/A	N/A	74.92 (3.64)	N/A	N/A	74.79 (3.57)	N/A	N/A
Span	154.21 (7.96)	153.06 (5.96)	<0.01	155.88 (7.03)	N/A	N/A	156.26 (6.63)	158.00 (10.2)	<0.01
Elbow span	78.74 (5.91)	78.35 (3.35)	<0.01	80.17 (5.41)	N/A	N/A	80.27 (5.45)	84.00 (7.87)	<0.01
Chest (bust) depth	26.89 (3.41)	20.27 (1.93)	<0.01	25.67 (3.43)	24.10 (3.70)	<0.01	24.8 (2.96)	23.00 (2.84)	<0.01
Chest (bust) breadth	28.77 (3.25)	27.12 (1.79)	<0.01	27.66 (3.16)	30.40 (2.40)	<0.01	26.87 (2.6)	N/A	N/A
Stand. e-to-e brt	47.41 (4.98)	N/A	N/A	45.27 (5.45)	N/A	N/A	44.16 (4.75)	N/A	N/A
Shoulder-elbow length	34.12 (2.53)	N/A	N/A	34.2 (2.48)	34.10 (2.00)	0.43	33.95 (2.13)	33.00 (2.89)	<0.01
Shoulder-fingertip lgth	71.71 (4.51)	N/A	N/A	71.60 (3.85)	N/A	N/A	71.34 (3.43)	N/A	N/A

Table 6.8. Comparison of results of present study with the studies for some other nations
(cont.).

Anthropometric Measurement	Present Study (2016) for manual workers 18-60 yrs	Datta et al. (2008) for 18-60 years	p-value (Datta et al. vs Present)	Present Study (2016) for 18-65 yrs	Hanson et al. (2009) for 18-65 yrs	p-value (Hanson et al. vs Present)	Present Study (2016) for 18-49 yrs	Chuan et al. (2010) for 18-45 years	p-value (Chuan et al. vs Present)
Shoulder-fist length	61.34 (4.68)	N/A	N/A	61.36 (4.11)	N/A	N/A	61.1 (3.69)	6.00 (3)	<0.01
Foot length	23.05 (1.28)	22.70 (0.96)	<0.01	23.36 (1.14)	24.30 (1.2)	<0.01	23.4 (1.16)	23.00 (0.89)	<0.01
Foot breadth	9.05 (0.66)	8.88 (0.60)	<0.01	9.08 (0.64)	9.10 (5.00)	0.89	9.03 (0.62)	9.00 (0.52)	0.19
Sitting height(e)	84.93 (3.85)	N/A	N/A	85.86 (3.86)	N/A	N/A	86.28 (3.83)	N/A	N/A
Sitting height (n)	84.16 (3.99)	80.28 (3.44)	<0.01	85.07 (3.95)	89.20 (3.50)	<0.01	85.5 (3.97)	85.00 (3.41)	0.28
Sitting eye height (e)	74.27 (3.71)	N/A	N/A	75.26 (3.89)	N/A	N/A	75.64 (3.96)	N/A	N/A
Sitting eye height (n)	73.48 (3.65)	68.74 (2.78)	<0.01	74.44 (3.84)	76.20 (3.30)	<0.01	74.81 (3.9)	74.00 (3.5)	0.63
Sitting shoulder ht (n)	59.4 (3.47)	54.61 (3.13)	<0.01	60.78 (3.45)	57.70 (2.90)	<0.01	59.78 (3.63)	58.00 (2.5)	<0.01
Sit. elbow rest ht (n)	25.83 (3.24)	23.39 (2.29)	<0.01	59.67 (3.48)	23.80 (2.70)	<0.01	26.23 (3.34)	25.00 (3.17)	<0.01
Knee height	46.83 (2.63)	45.29 (2.41)	<0.01	26.07 (3.12)	52.10 (3.10)	<0.01	47.43 (2.36)	49.00 (2.18)	<0.01
Popliteal height	37.78 (2.02)	35.31 (1.86)	<0.01	47.37 (2.48)	N/A	N/A	38.32 (1.77)	4.00 (1.32)	<0.01
Buttock-knee length	55.18 (3.46)	50.51 (2.59)	<0.01	38.15 (1.99)	59.60 (3.70)	<0.01	55.35 (2.84)	54.00 (2.72)	<0.01
Buttock-popliteal lgt	46.83 (2.65)	38.16 (2.98)	<0.01	55.47 (3.04)	47.70 (3.00)	<0.01	46.08 (2.32)	45.00 (2.19)	<0.01
Thigh clearance	13.73 (1.67)	14.26 (1.37)	<0.01	46.39 (2.43)	14.50 (1.50)	<0.01	13.58 (1.48)	14.00 (1.33)	<0.01
Buttock-Leg Length	93.74 (4.58)	N/A	N/A	13.64 (1.52)	N/A	N/A	94.58 (4.43)	N/A	N/A
Sit.vertical grip rch	115.51 (5.53)	111.00 (4.20)	<0.01	94.66 (4.56)	N/A	N/A	116.21 (4.78)	116.00 (5.45)	0.81
Sit.vertical th-tip rch	119.45 (5.77)	N/A	N/A	116.13 (5.02)	N/A	N/A	120.36 (4.91)	N/A	N/A
Sit.vertical fngtip rch	124.5 (5.53)	N/A	N/A	120.22 (5.15)	N/A	N/A	125.67 (4.9)	N/A	N/A
Sit.forward grip rch	65.24 (3.19)	N/A	N/A	125.44 (5.16)	N/A	N/A	65.31 (3.37)	N/A	N/A
Sit.forward th-tip rch	69.44 (3.54)	N/A	N/A	65.43 (3.27)	N/A	N/A	69.47 (3.61)	N/A	N/A
Sit.forward fngtip rch	74.88 (3.74)	N/A	N/A	69.61 (3.49)	N/A	N/A	75.15 (3.84)	N/A	N/A
Head circumference	55.34 (1.74)	N/A	N/A	75.24 (3.72)	55.50 (1.40)	0.41	55.34 (1.67)	N/A	N/A
Head length	17.82 (0.88)	18.52 (0.65)	<0.01	55.39 (1.73)	19.00 (8.00)	0.01	17.92 (0.84)	18.00 (0.74)	0.08
Head breadth	14.99 (0.74)	14.79 (0.77)	<0.01	17.87 (0.86)	14.60 (5.00)	0.12	15.03 (0.71)	16.00 (0.66)	<0.01
Ment-sellion (face) lgt	11.94 (0.93)	N/A	N/A	15.03 (0.73)	N/A	N/A	11.83 (0.78)	N/A	N/A
Bizygomatic (face) brt	12.79 (0.69)	N/A	N/A	12.69 (0.67)	N/A	N/A	12.6 (0.64)	N/A	N/A
Neck circumference	33.9 (2.13)	N/A	N/A	33.27 (2.18)	N/A	N/A	32.87 (2.07)	N/A	N/A
Chest circumference	100.13(10.58)	85.02 (6.37)	<0.01	96.05 (10.82)	N/A	N/A	93.23 (8.72)	N/A	N/A
Waist circumference	89.61 (12.32)	75.48 (6.11)	<0.01	83.95 (12.29)	N/A	N/A	80.43 (9.65)	N/A	N/A
Hip breadth (sitting)	38.43 (3.7)	31.12 (2.04)	<0.01	37.83 (3.61)	41.60 (3.00)	<0.01	37.2 (3.23)	35.00 (2.32)	<0.01
Sit. e-to-e brt (n)	46.91 (5.16)	37.59 (2.98)	<0.01	45.08 (5.11)	N/A	N/A	44.02 (4.37)	N/A	N/A

Table 6.8. Comparison of results of present study with the studies for some other nations
(cont.).

Anthropometric Measurement	Present Study (2016) for manuel workers 18-60 yrs	Datta et al. (2008) for 18-60 years	p-value (Datta et al. vs Present)	Present Study (2016) for 18-65 yrs	Hanson et al. (2009) for 18-65 yrs	p-value (Hanson et al. vs Present)	Present Study (2016) for 18-49 yrs	Chuan et al. (2010) for 18-45 years	p-value (Chuan et al. vs Present)
Shld biacr. brt	35.06 (2.77)	33.49 (1.85)	<0.01	35.15 (2.58)	35.60 (1.90)	0.01	35.24 (2.51)	34.00 (2.58)	<0.01
Shld bideltoid brt	42.16 (3.4)	36.52 (2.19)	<0.01	41.44 (3.33)	42.50 (2.30)	<0.01	40.97 (2.98)	4.00 (2.51)	<0.01
Hand length	17.2 (1.06)	16.53 (0.73)	<0.01	17.20 (0.99)	17.90 (9.00)	0.15	17.19 (0.97)	17.00 (0.68)	0.01
Hand breadth	8.04 (0.53)	6.49 (0.30)	<0.01	7.95 (0.52)	7.80 (4.00)	0.43	7.87 (0.45)	7.00 (0.62)	<0.01
Palm lgt perp	9.56 (0.67)	9.11 (0.43)	<0.01	9.57 (0.60)	N/A	N/A	9.54 (0.59)	N/A	N/A
Index finger length	6.94 (0.48)	N/A	N/A	7.01 (0.52)	N/A	N/A	7.01 (0.52)	N/A	N/A
Hand Circumference	19.78 (1.08)	N/A	N/A	19.47 (1.16)	N/A	N/A	19.26 (1.07)	N/A	N/A
Wrist circumference	16.42 (1.2)	14.71 (0.80)	<0.01	16.08 (1.20)	N/A	N/A	15.88 (1.09)	N/A	N/A

6.2.2. Comparison with Previous Studies of Population of Turkey

Table 6.9 shows mean and standard deviation values of former studies about anthropometric measurements of population of Turkey for each age group. The empty cells (N/A) in the tables mean that there is no information available. There are different age groups in each study; and measurement values are different for the same age group for different nations. By this context, it is important to determine age ranges and compare studies in same conditions. It should be noted that the most comprehensive studies in literature on anthropometric measurements are available for Turkish male population only.

In Table 6.10, the comparison results of Güleç *et al.* (2006), İşeri and Arslan (2009) and male sample of Eren (2012) with the current study for matching anthropometric measurements are presented. To compare the study with other studies in an accurate way, total female population was taken into consideration. The comparison made with Eren (2012) was to show the difference of Turkish female and male population in all dimensions, since Eren (2012) studied Turkish male adults through 18-70 years. T-test was used to demonstrate the difference.

According to Table 6.10, the comparison results of Güleç *et al.* (2006) with the present study, there are significant differences in 11 measurements between these two studies. However, the differences are very small, for some measurements in millimeters. One important result is that in the present study, stature is about 1.50 cm greater than in Güleç *et al.* (2006). It may be concluded that this result comes from the differences in measurement techniques, distribution of subjects and yet again due to the large differences in sample sizes, else simply Turkish adult females may have got taller in 9 years in height.

The comparison of results between Iseri and Arslan (2009) and present study indicate that there is significant difference between almost all dimensions. Most of the vertical dimensions were greater in the results of Iseri and Arslan (2009) than in the present study. This could be explained by the estimation method of measurements, since Işeri and Arslan (2009)'s data were based on self reported survey values, instead of actual measurements.

The results of the present study indicate that there is a decrease in body mass of adult female population of Turkey for 18-49 years when compared to Gönen *et al.* (1991) up to now from 1990s, and it is nearly 4 kg. In addition, body mass has decreased almost 0.6 kg from 2006 until now for adult female Turkish population. It may be mostly because of increase in the activity level, dietary, societal changes and change in daily habits resulted from technological development in Turkey. In addition, female population of Turkey for the same age group has been taller as 1.65 cm up to now from 1990s. This change in twenty-four years may be resulted from change in work styles and then decrease in usage of human work force as much as in previous work styles.

Measurement results of present study and Eren (2012) on Turkish adult males between 18-70 years present that, all measurements except, chest circumference and hip breadth are significantly different. In addition, the difference in elbow rest height was marginally significant. Measurement techniques, distribution of subjects with respect to age group and job-group, and sample sizes were the same in both studies. Therefore, calculated differences can be clearly attributed to gender differences. The only measurement smaller in size for Turkish adult males is chest depth taken from nipple. For all other significant differences, relevant measurement value is greater for males than for females. Although the differences in chest circumference and hip breadth between Turkish

females and males are not significant, they were greater in value for female population. For chest circumference, it was expected that the measurement would be greater for females significantly. However, Turkish males were wider in breadth dimensions than females; therefore, the greatness in chest breadth for Turkish males may have compensated the greatness in chest depth for Turkish females. This could be the reason why the difference of chest circumference between females and males was not significant.

Table 6.9. Stature and body mass values of female population of Turkey.

Source	Age-group	Stature (cm)	Body Mass (kg)
		$\bar{x}(s)$	$\bar{x}(s)$
Present Study (2016)	Overall (18-60-79 yrs)	157.02 (6.62)	66.50 (12.99)
	18-29 yrs	160.67 (6.82)	59.19 (11.22)
	30-39 yrs	158.55 (4.99)	65.96 (13.88)
	40-49 yrs	154.81 (6.17)	64.85 (10.88)
	50-59 yrs	156.58 (6.14)	71.60 (11.97)
	60-79 yrs	153.63 (6.67)	72.16 (12.81)
Gönen et al. (1991) (General population)	20-45 yrs	156.49 (5.36)	67.40 (13.38)
Güleç et al. (2006) (General population)	20-65 yrs	155.03 (5.93)	67.12 (14.17)
Burdurlu et al. (2006) (Children)	12 yrs	150.40 (6.50)	N/A
	13 yrs	159.10 (8.30)	N/A
	14 yrs	167.10 (8.10)	N/A
	15 yrs	174.90 (7.10)	N/A
Ozer et al. (2007)	18-30 yrs	162.63 (6.24)	N/A
	31-40 yrs	158.13 (5.08)	N/A
	41-50 yrs	156.71 (4.46)	N/A
	51-64 yrs	155.40 (5.62)	N/A
	65+ yrs	149.56 (6.31)	N/A
Neyzi et al. (2008) (Children)	3 mnths	59.60 (N/A)	5.80 (N/A)
	6 mnths	66.40 (N/A)	7.40 (N/A)
	1 yr	75.10 (N/A)	9.40 (N/A)
	3 yrs	95.40 (N/A)	14.20 (N/A)
	6 yrs	115.10 (N/A)	20.60 (N/A)
	9 yrs	132.10 (N/A)	28.90 (N/A)
	12 yrs	153.10 (N/A)	45.10 (N/A)
	15 yrs	161.10 (N/A)	55.30 (N/A)
	17 yrs	162.70 (N/A)	57.20 (N/A)
Ayan (2008) (Female children)	8-10 yrs	131.86 (6.33)	29.54 (6.48)
İşeri and Arslan (2009) (General population)	18-69 yrs	159.8 (7.60)	65.00 (13.00)

Table 6.10 Comparison of results of the studies about population of Turkey.

Anthropometric Measurement	Present Study (2016) for 18-60-79 yrs	Güleç <i>et al.</i> (2006) for 20-65 yrs	p-value (Güleç vs Present)	Iseri and Arslan (2009) for 18-69 yrs	p-value (Iseri and Arslan vs Present)	Eren (2012) for males 18-70 yrs	p-value (Eren vs Present)
Body mass (kg)	66.50 (12.99)	67.12 (14.17)	0.53	65.00 (8.60)	0.02	76.6 (12.8)	<0.01
Stature (e)	157.02 (6.62)	N/A	N/A	N/A	N/A	171.5 (8.1)	<0.01
Stature (n)	156.65 (6.54)	155.03 (5.93)	<0.01	159.8 (7.60)	<0.01	171.1(8.0)	<0.01
Eye height (e)	146.51 (6.71)	N/A	N/A	N/A	N/A	160.7 (8.2)	<0.01
Eye height (n)	145.73 (6.65)	N/A	N/A	149.20 (7.30)	<0.01	160.3 (8.1)	<0.01
Acr. (shld) ht (e)	132 (5.88)	N/A	N/A	N/A	N/A	142.8 (7.5)	<0.01
Acr. (shld) ht (n)	131.15 (6.13)	N/A	N/A	130.70 (7.10)	0.34	141.2 (7.1)	<0.01
Elbow height (n)	96.28 (5.03)	N/A	N/A	100.30 (5.50)	<0.01	106.2 (6.1)	<0.01
Fingertip height (n)	59.36 (3.91)	N/A	N/A	62.80 (4.70)	<0.01	63.8 (4.4)	<0.01
Thumb-tip height (n)	65.19 (3.86)	N/A	N/A	N/A	N/A	69.2 (4.4)	<0.01
Fist(gr.ax, knck)ht (n)	69.8 (4.12)	N/A	N/A	72.40 (4.50)	<0.01	75.8 (4.8)	<0.01
Waist height (n)	89.52 (5.25)	N/A	N/A	N/A	N/A	102.7 (7.0)	<0.01
Vertical grip rch	185.92 (8.56)	N/A	N/A	188.10 (8.80)	<0.01	203.9(11.0)	<0.01
Vertical th-tip rch	190.68 (8.65)	N/A	N/A	N/A	N/A	209.0(11.3)	<0.01
Vertical fngtip rch	195.93 (8.77)	N/A	N/A	N/A	N/A	214.9(11.5)	<0.01
Forward grip rch	64.52 (3.11)	N/A	N/A	69.50 (4.20)	<0.01	74.1 (4.2)	<0.01
Forward th-tip rch	68.99 (3.55)	N/A	N/A	N/A	N/A	80.1 (4.8)	<0.01
Forward fngtip rch	74.81 (3.76)	N/A	N/A	N/A	N/A	86.6 (4.8)	<0.01
Span	155.46 (7.29)	N/A	N/A	159.30 (8.70)	<0.01	173.0 (8.6)	<0.01
Elbow span	79.73 (5.56)	N/A	N/A	84.20 (5.30)	<0.01	90.4 (5.2)	<0.01
Chest (bust) depth	26.02 (3.52)	N/A	N/A	25.90 (2.70)	0.52	22.4 (2.6)	<0.01
Chest (bust) breadth	28.01 (3.28)	26.91 (2.80)	<0.01	N/A	N/A	30.4 (3.5)	<0.01
Stand. e-to-e brt	46 (5.59)	N/A	N/A	N/A	N/A	50.8 (4.8)	<0.01
Shoulder-elbow length	34.24 (2.49)	N/A	N/A	27.30 (3.20)	<0.01	36.6 (4.4)	<0.01
Shoulder-fingertip lgth	71.72 (3.91)	N/A	N/A	N/A	N/A	79.0 (5.3)	<0.01
Shoulder-fist length	61.47 (4.22)	N/A	N/A	59.60 (3.60)	<0.01	67.0 (5.6)	<0.01
Foot length	23.28 (1.19)	23.62 (1.23)	<0.01	23.20 (1.40)	0.39	25.6 (1.5)	<0.01
Foot breadth	9.06 (0.63)	9.17 (0.72)	0.03	8.80 (0.70)	<0.01	9.9 (0.8)	<0.01
Sitting height(e)	85.47 (3.97)	N/A	N/A	N/A	N/A	90.2 (3.9)	<0.01
Sitting height (n)	84.68 (4.04)	88.73 (3.64)	<0.01	84.80 (4.10)	0.66	89.8 (3.9)	<0.01
Sitting eye height (e)	74.94 (3.97)	N/A	N/A	N/A	N/A	79.7 (4.0)	<0.01
Sitting eye height (n)	74.14 (3.91)	N/A	N/A	73.70 (3.90)	0.09	79.3 (4.0)	<0.01
Sitting shoulder ht (e)	60.61 (3.52)	N/A	N/A	N/A	N/A	61.7 (3.8)	<0.01

Table 6.10 Comparison of results of the studies about population of Turkey (cont.).

Anthropometric Measurement	Present Study (2016) for 18-60-79 yrs	Güleç <i>et al.</i> (2006) for 20-65 yrs	p-value (Güleç vs Present)	Iseri and Arslan (2009) for 18-69 yrs	p-value (Iseri and Arslan vs Present)	Eren (2012) for males 18-70 yrs	p-value (Eren vs Present)
Sitting shoulder ht (n)	59.53 (3.51)	N/A	N/A	55.80 (3.6)	<0.01	60.4 (3.9)	0.01
Sit. elbow rest ht (n)	25.86 (3.22)	N/A	N/A	23.20 (3.40)	<0.01	26.4 (3.4)	0.07
Knee height	47.24 (2.51)	47.76 (2.30)	<0.01	N/A	N/A	51.3 (3.3)	<0.01
Popliteal height	38.02 (1.98)	N/A	N/A	39.50 (3.10)	<0.01	42.2 (3.2)	<0.01
Buttock-knee length	55.43 (3.21)	54.84 (2.96)	0.01	56.90 (3.60)	<0.01	59.8 (3.5)	<0.01
Buttock-popliteal lgt	46.57 (2.56)	N/A	N/A	47.50 (3.60)	<0.01	49.8 (3.9)	<0.01
Thigh clearance	13.65 (1.53)	N/A	N/A	15.30 (2.10)	<0.01	15.8 (1.9)	<0.01
Buttock-Leg Length	94.45 (4.72)	N/A	N/A	N/A	N/A	105.0 (5.4)	<0.01
Sit.vertical grip rch	115.93 (5.12)	N/A	N/A	114.10 (6.50)	<0.01	122.5 (7.2)	<0.01
Sit.vertical th-tip rch	119.9 (5.29)	N/A	N/A	N/A	N/A	127.4 (7.4)	<0.01
Sit.vertical fngtip rch	125.16 (5.25)	N/A	N/A	N/A	N/A	133.7 (7.4)	<0.01
Sit.forward grip rch	65.46 (3.38)	N/A	N/A	N/A	N/A	73.4 (5.4)	<0.01
Sit.forward th-tip rch	69.6 (3.59)	N/A	N/A	N/A	N/A	78.9 (5.6)	<0.01
Sit.forward fngtip rch	75.19 (3.81)	N/A	N/A	N/A	N/A	84.9 (5.9)	<0.01
Head circumference	55.4 (1.69)	N/A	N/A	N/A	N/A	56.7 (4.2)	<0.01
Head length	17.89 (0.85)	17.68 (0.71)	<0.01	17.80 (0.80)	0.10	18.8 (1.6)	<0.01
Head breadth	15.04 (0.73)	14.85 (0.77)	<0.01	15.30 (0.80)	<0.01	15.8 (1.3)	<0.01
Ment-sellion (face) lgt	11.84 (0.84)	N/A	N/A	N/A	N/A	12.3 (1.1)	<0.01
Bizygomatic (face) brt	12.73 (0.68)	N/A	N/A	N/A	N/A	13.0 (1.2)	<0.01
Neck circumference	33.49 (2.23)	33.81 (2.86)	0.10	N/A	N/A	38.2 (3.8)	<0.01
Chest circumference	97.32 (11.2)	N/A	N/A	N/A	N/A	96.1 (10.1)	0.20
Waist circumference	85.97 (13.17)	86.91 (14.04)	0.34	N/A	N/A	90.4 (12.0)	<0.01
Hip breadth (sitting)	37.96 (3.51)	N/A	N/A	N/A	N/A	37.8 (3.9)	0.63
Sit. e-to-e brt (n)	45.75 (5.31)	N/A	N/A	N/A	N/A	51.4 (6.2)	<0.01
Shld biacr. brt	35.11 (2.59)	36.11 (2.30)	<0.01	35.30 (2.30)	0.23	38.3 (2.2)	<0.01
Shld bideltoid brt	41.59 (3.36)	N/A	N/A	36.60 (2.40)	<0.01	45.8 (3.4)	<0.01
Hand length	17.17 (0.97)	18.03 (1.06)	<0.01	16.70 (1.00)	<0.01	18.8 (1.7)	<0.01
Hand breadth	7.98 (0.51)	7.63 (0.53)	<0.01	7.50 (0.60)	<0.01	8.8 (0.8)	<0.01
Palm lgt perp	9.57 (0.63)	N/A	N/A	N/A	N/A	10.6 (0.9)	<0.01
Index finger length	6.97 (0.52)	N/A	N/A	N/A	N/A	7.3 (0.7)	<0.01
Hand Circumference	19.53 (1.17)	N/A	N/A	N/A	N/A	21.4 (2.2)	<0.01
Wrist circumference	16.19 (1.22)	16.48 (1.35)	<0.01	N/A	N/A	17.8 (2.2)	<0.01

7. CONCLUSIONS

For adult female population of Turkey, an up-to-date anthropometric database consisting of 65 body measurements is developed. The summary of the findings drawn from this study in terms of the objectives based on the results are as follows:

- (i) In order to be used by both practitioners and researchers, an up-to-date anthropometric database including 65 static and dynamic body measurements for adult female population of Turkey is established.
- (ii) There is 1.5 cm increase in average stature in comparison to 2006 stature indicating a secular trend.
- (iii) Stature and other vertical body dimensions as well as length dimensions are significantly decreasing with age. Some breadth, depth and circumference dimensions significantly increase with age.
- (iv) There is no significant difference between the average body mass found through the present study and the average body mass reported by a 2006 study of female population of Turkey.
- (v) There is a high rate (62%) of overweight people among female population of Turkey.
- (vi) When compared to the results of other nationalities anthropometric data of the female population of Turkey, in general, is similar to the Algerian and Cuban, greater than Malasians, Chinese and Thai adults and lower than Northern Europeans.

7.1. Contributions and Recommendations to Practitioners

The established anthropometry database through this study can serve as a reference for many applications including workwear, workspace, architectural, product, and vehicle designs for adult female population of Turkey.

The percentile tables in this manuscript can be used as references by the designers in various areas that require human body measurement values. The necessary data can be

retrieved to design to fit, in general, from 5th to 95th %tile of adult female population of Turkey. The designs based on the anthropometric data will be comfortable, safe and efficient.

7.2. Limitations of the Current Study

Current study has the following limitations:

- Subject participated to this study were living in the metropolitan city of Istanbul and its surrounding areas although the family roots of the participants included every region of Turkey. Therefore, the effects of living environment of the subjects were assumed negligible.
- Subjects over 79 years old were not considered in this study.

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APPENDIX A: FORMS

Appendix section includes the forms that were used in the study. These forms are personal consent form, brief medical history form, data collection form and the form of design.

A.1 and A.2: Brief medical history form was prepared for subjects to check if they were healthy enough to participate in the study. This form was prepared in both languages.

A.3 and A.4: Personal consent form is prepared in both English and Turkish and detailed description of the aim and procedures of the study are included in this form. In order to participate in the study, all of the participants voluntarily signed the form.

A.5: In order to record the descriptive and anthropometric measurement data of the subjects, a data collection form is used for during the studies.

A.6 and A.7: Instructions were prepared in both English and Turkish for the subjects in order to inform them about the testing procedure.

A.1. Brief Medical History Form

Answer the questions, please. Check if answer is “yes”. Give detailed information if it is necessary, please.

- Do you have any defect on your body dimensions such as a burned place?
- Is there any deficiency on your body dimensions such as deficiency in hand, leg, finger...etc.?
- Do you have any difficulty resulted from your anthropometric structure while working?
- Have you ever been undergone an operation resulted in limitation your body motion especially while working?
- How often do you have inspection related to your health?

Please give information about any other problem that affects your abilities while working.

A.2. Sağlık Anketi

Aşağıdaki soruları lütfen cevaplayınız. Eğer, cevabınız “evet” ise çarpı işaretiyle işaretleyiniz. Gerek duyuluyorsa, cevabınız hakkında lütfen detaylı bilgi veriniz.

- Vücut boyutlarınızda herhangi bir sorun var mı; örneğin yanık bir alan?
- Vücut boyutlarınızda herhangi bir eksiklik var mı; örneğin elinizde, bacağınızda, parmaklarınızda eksiklik olması gibi?
- Vücut anatominizden kaynaklanan sebeplerden dolayı, çalışırken herhangi bir zorluk yaşıyor musunuz?
- Özellikle çalışma esnasında vücut hareketlerinizi kısıtlayan herhangi bir ameliyat geçirdiniz mi?
- Ne kadar sıklıkla sağlık kontrolünden geçiyorsunuz?

Yukarıda belirtilenler dışında, çalışırken yeterliliğinizi etkileyen herhangi bir sorun yaşıyorsanız lütfen belirtiniz.

A.3. Personal Consent Form

In this study, 64 body measurements including body mass will be determined for the adult female population of Turkey. You are an eligible participant for this study because you do not have any serious health problems that affect your performance especially for reaching postures in this study.

The anthropometric results of this study will be useful for designing workplace and seated places; also hand tools and shoes for male adults in Turkey. The designs that are done by using these results may lead to higher productivity, human centered products and reduced risk of work related disorders.

If you decide to participate in the study, please be aware of the following issues:

- (i) Before the tests, you will be asked questions about birth date, birthplace, the place you live now, family origin city, mother and father's birthplace, your ethnicity, occupation, education status, marital status, frequency of smoking/drinking habit, frequency of sportive activities and controls on your health, genetic disorders.
- (ii) The tests will be done in random order and at the end; there will be 64 body measurements. When you are ready for the study, you will have the appropriate posture without any motion to be measured by the experimenter.
- (iii) Before the tests, participants should not be too hungry, too full or sleepless, and should not consume harmful substances. Moreover, they must be healthy enough to perform the tests.

Your participation is completely voluntary. You may choose to withdraw from participation at any time. All information obtained during this study will be held in strict confidence and only the mean and standard deviation values of the data will be used in the study.

If at any time you have questions regarding this research or if you want to add some contributions to this research, you may contact either Cansu ERGÜN or Assoc. Prof. Mahmut EKŞİOĞLU from Department of Industrial Engineering, Boğaziçi University.

By placing your signature below, you will accept that your participation to this study is voluntary. However, you can choose to withdraw from participation at any time at no cost or obligation to you.

Signature of Participant:

Date:

A.4. Kişisel Kabul Formu

Bu çalışmada, Türk yetişkin kadın nüfusu için vücut ağırlığını da içerek şekilde 64 adet vücut ölçüsü alınacaktır. Bu çalışmaya engel olacak herhangi bir sağlık probleminizin olmamasından dolayı, çalışmaya uygun durumda bulunmaktasınız.

Çalışmadan elde edilecek antropometrik sonuçlar, iş istasyonları, oturma alanları, el araçları ve ayakkabıların Türkiye insanına göre tasarlanmasında faydalı olacaktır. Bu verileri kullanarak yapılacak tasarımlar hem iş verimini arttırmaya yardımcı olacak hem de iş hastalıklarını azaltmada katkı sağlayacaktır.

Deneye katılmaya karar verdiyseniz lütfen aşağıdaki konulara dikkat ediniz:

- (i) Deney öncesinde size doğum tarihiniz, doğduğunuz ve şu an yaşadığınız yer, aile kökeniniz, anne babanızın doğum yeri, etnik kökeniniz, mesleğiniz, eğitim durumunuz, medeni haliniz, sigara/alkol kullanma sıklığınız, sportif aktivite yapma sıklığınız ve genetik rahatsızlıklarınız sorulacaktır.
- (ii) Rassal sırayla yapılacak olan testlerde 64 vücut ölçüsü alınacaktır. Deney için hazır olduğunuz aman, vücut pozisyonu deney yürütücüsü tarafından size gösterilecektir.
- (iii) Deneylerden önce çok aç, fazla tok veya uykusuz olunmamalı, zararlı maddeler tüketilmemelidir. Ayrıca gerekli olan sağlık şartlarına sahip olmanız gerekmektedir.

Bu deneye katılım tamamen gönüllüdür ve katılım için bir zorlama ile karşılaşmanız söz konusu değildir. İstedığınızde çalışmanın herhangi bir aşamasında çalışmayı terk edebilirsiniz. Elde edilecek kişisel bilgiler kimseyle paylaşılmayacak, tez çalışmasında sadece verilerin ortalaması (kime ait olduğu belirtilmeksizin) ve maksimum ve minimum değerleri belirtilecektir.

Bu çalışmayla ilgili sorularınız ve katkılarınız olması durumunda Boğaziçi Üniversitesi Endüstri Mühendisliği Bölümü'nde Cansu ERGÜN veya Doç. Dr. Mahmut EKŞİOĞLU ile temasa geçebilirsiniz

Aşağıya atacağınız imza, bu çalışmaya gönüllü olarak katılmak istediğinizi belirtmektedir. Ayrıca çalışmayı yarıda bırakmanız durumunda, size herhangi bir yükümlülük getirmemektedir.

Katılımcının İmzası:

Tarih:

A.5. Personel Data Form

Table A.1. General information about the subject.

Information	Datum
Birth date	Day: Month: Year:
Birthplace	
The place she/he lives now	
Family origin city	
Mother and father's birthplace	
Ethnicity	
Occupation	
Education Status	
Marital Status	
Frequency of Smoking habit	
Frequency of Drinking habit	
Frequency of Sportive activities	
Dominant Side	
Frequency of controls on your health	

Table A.2. Anthropometric measurements of the subject.

Body mass (kg)	
Stature (erect)	
Stature (normal)	
Eye height (erect)	
Eye height (normal)	
Acromial (shoulder) height (erect)	
Acromial (shoulder) height (normal)	
Elbow height (normal)	
Fingertip height (normal)	
Thumb-tip height (normal)	
Fist (grip axis) height (normal)	
Waist height (normal)	
Vertical grip reach	
Vertical thumb-tip reach	
Vertical fingertip reach	
Forward grip reach	
Forward thumb-tip reach	
Forward fingertip reach	
Span	
Elbow span	
Chest (bust) depth	
Chest (bust) breadth	
Standing elbow-to-elbow breadth	
Shoulder-elbow length	
Shoulder-fingertip length	
Shoulder-grip axis length	
Foot length	
Foot breadth	
Sitting height(erect)	
Sitting height (normal)	
Sitting eye height (erect)	
Sitting eye height (normal)	

Table A.2. Anthropometric measurements of the subject (cont.).

Sitting acromial (shoulder) height (erect)	
Sitting acromial (shoulder) height (normal)	
Sitting elbow rest height (normal)	
Knee height	
Popliteal height	
Buttock-knee length	
Buttock-popliteal length	
Thigh clearance	
Buttock-Leg Length	
Sitting vertical grip reach	
Sitting vertical thumb-tip reach	
Sitting vertical fingertip reach	
Sitting forward grip reach	
Sitting forward thumb-tip reach	
Sitting forward fingertip reach	
Head circumference	
Head length	
Head breadth	
Menton-sellion (face) length	
Bizygomatic (face) breadth	
Neck circumference	
Chest circumference	
Waist circumference	
Hip breadth (sitting)	
Sitting elbow-to elbow breadth (normal)	
Shoulder biacromial breadth	
Shoulder bideltoid breadth	
Hand length	
Hand breadth	
Palm length perpendicular	
Index finger length	
Hand Circumference	
Wrist circumference	

A.6. Instructions

- (i) You have read the personal consent form and received information about the study.
- (ii) At the beginning of the study, you should give general information about yourselves which are asked by the experimenter.
- (iv) The experimenter will show you the appropriate posture for each measurement.
- (iv) When you are ready for the studies, inform the experimenter.
- (v) You should have the posture shown by the experimenter without doing any motion through the study.

A.7. Talimatlar

- (i) Kişisel kabul formunu okudunuz ve deney hakkında bilgi edindiniz.
- (ii) Deneyin başlangıcında, deneyi yaptıran kişi tarafından sizin hakkında genel sorular sorulacaktır.
- (iii) Her ölçüm için uygun pozisyon deneyi yaptıran kişi tarafından size gösterilecektir.
- (iv) Deneye başlamaya hazır olduğunuzda bunu belirtiniz.
- (v) Deneyi yaptıran kişi tarafından size gösterilen vücut duruşunu deney süresince bozmamaya özen gösterin.

APPENDIX B: RESULTS OF STATISTICAL ANALYSIS

B.1. ANOVA Assumptions

Table B.1. Checking in ANOVA Assumptions.

	Anderson-Darling Results	Barlett's Test Results
Body mass (kg)	0.938	0.074
Stature (erect)	0.826	0.270
Stature (normal)	0.863	0.296
Eye height (erect)	0.244	0.116
Eye height (normal)	0.278	0.142
Acromial (shoulder) height (erect)	0.638	0.071
Acromial (shoulder) height (normal)	0.258	0.060
Elbow height (normal)	0.063	0.052
Fingertip height (normal)	0.181	0.272
Thumb-tip height (normal)	0.119	0.448
Fist (grip axis, knuckle) height (normal)	0.157	0.107
Waist height (normal)	0.213	0.304
Vertical grip reach	0.255	0.074
Vertical thumb-tip reach	0.152	0.055
Vertical fingertip reach	0.254	0.088
Forward grip reach	0.180	0.326
Forward thumb-tip reach	0.152	0.660
Forward fingertip reach	0.392	0.332
Span	0.153	0.488
Elbow span	0.871	0.069
Chest (bust) depth	0.064	0.061
Chest (bust) breadth	0.055	0.084
Standing elbow-to-elbow breadth	0.683	0.788
Shoulder-elbow length	0.063	0.058
Shoulder-fingertip length	0.069	0.077
Shoulder-grip axis length	0.061	0.092
Foot length	0.391	0.103
Foot breadth	0.101	0.331
Sitting height(erect)	0.517	0.897
Sitting height (normal)	0.611	0.753
Sitting eye height (erect)	0.402	0.162
Sitting eye height (normal)	0.319	0.163
Sitting acromial (shoulder) height (erect)	0.958	0.350
Sitting acromial (shoulder) height (normal)	0.955	0.491
Sitting elbow rest height (normal)	0.609	0.090
Knee height	0.574	0.477
Popliteal height	0.509	0.230
Buttock-knee length	0.068	0.065
Buttock-popliteal length	0.515	0.128
Thigh clearance	0.323	0.057
Buttock-leg length	0.077	0.095
Sitting vertical grip reach	0.573	0.180
Sitting vertical thumb-tip reach	0.967	0.078
Sitting vertical fingertip reach	0.340	0.336
Sitting forward grip reach	0.055	0.340

Table B.1. Checking in ANOVA Assumptions (cont.).

	Anderson-Darling Results	Barlett's Test Results
Sitting forward thumb-tip reach	0.084	0.430
Sitting forward fingertip reach	0.166	0.472
Head circumference	0.254	0.089
Head length	0.061	0.081
Head breadth	0.058	0.058
Menton-sellion (face) length	0.074	0.153
Bizygomatic (face) breadth	0.088	0.724
Neck circumference	0.102	0.056
Chest circumference	0.256	0.109
Waist circumference	0.479	0.059
Hip breadth (sitting)	0.245	0.735
Sitting elbow-to elbow breadth (normal)	0.054	0.053
Shoulder biacromial breadth	0.233	0.227
Shoulder bideltoid breadth	0.203	0.084
Hand length	0.148	0.096
Hand breadth	0.322	0.136
Palm length perpendicular	0.394	0.142
Index finger length	0.221	0.078
Hand circumference	0.451	0.793
Wrist circumference	0.488	0.438

B.2. Post-Hoc Analysis and Regression Models

Table B.2. Tukey's test results for agegroup differences in body mass

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	6.77	(0.36)-(13.19)	2.35	0.032
(40-49)-(18-29)	5.66	(-0.89)-(12.21)	2.40	0.127
(50-59)-(18-29)	12.41	(5.93)-(18.89)	2.37	<0.001
(60-79)-(18-29)	12.96	(6.30)-(19.63)	2.44	<0.001
(40-49)-(30-39)	-1.11	(-7.75)-(5.53)	2.43	0.991
(50-59)-(30-39)	5.64	(-0.93)-(12.21)	2.41	0.132
(60-79)-(30-39)	6.19	(-0.56)-(12.95)	2.47	0.090
(50-59)-(40-49)	6.75	(0.04)-(13.45)	2.46	0.047
(60-79)-(40-49)	7.30	(0.42)-(14.18)	2.52	0.031
(60-79)-(50-59)	0.56	(-6.26)-(7.37)	2.50	0.999

Table B.3 Tukey's test results for job-group differences in body mass

Job Group Difference	Difference of Means	CI for Means		P-value
(Non-Manual)-(Manual)	-1.62	(-4.86)-(1.62)	1.64	0.324

Table B.4 Tukey's test results for age-group differences in stature (normal)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.10	(-5.31)- (1.11)	1.18	0.381
(40-49)-(18-29)	-5.83	(-9.11)- (-2.55)	1.20	<0.001
(50-59)-(18-29)	-3.99	(-7.24)- (-0.75)	1.19	0.007
(60-79)-(18-29)	-6.94	(-10.27)- (-3.60)	1.22	<0.001
(40-49)-(30-39)	-3.73	(-7.05)- (-0.41)	1.22	0.019
(50-59)-(30-39)	-1.89	(-5.18)- (1.40)	1.20	0.517
(60-79)-(30-39)	-4.83	(-8.21)- (-1.45)	1.24	0.001
(50-59)-(40-49)	1.84	(-1.52)- (5.19)	1.23	0.565
(60-79)-(40-49)	-1.10	(-4.55)- (2.34)	1.26	0.906
(60-79)-(50-59)	-2.94	(-6.35)- (0.47)	1.25	0.128

Table B.5 Tukey's test resultss for age-group differences in eye ht (normal)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.51	(-5.80)- (0.77)	1.20	0.225
(40-49)-(18-29)	-5.82	(-9.18)- (-2.47)	1.23	<0.001
(50-59)-(18-29)	-3.89	(-7.21)- (-0.57)	1.22	0.012
(60-79)-(18-29)	-6.96	(-10.37)- (-3.54)	1.25	<0.001
(40-49)-(30-39)	-3.31	(-6.71)- (0.09)	1.25	0.061
(50-59)-(30-39)	-1.38	(-4.74)- (1.99)	1.23	0.798
(60-79)-(30-39)	-4.44	(-7.90)- (-0.99)	1.27	0.004
(50-59)-(40-49)	1.93	(-1.50)- (5.36)	1.26	0.538
(60-79)-(40-49)	-1.13	(-4.66)- (2.39)	1.29	0.905
(60-79)-(50-59)	-3.07	(-6.56)- (0.42)	1.28	0.116

Table B.6 Tukey's test resultss for BMI-group differences in eye ht (normal)

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	-3.768	(-5.408)- (-2.128)	0.833	<0.001

Table B.7 Tukey's test results for age-group differences in acromial shoulder ht (normal)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.01	(-5.15)- (1.13)	1.15	0.404
(40-49)-(18-29)	-4.88	(-8.09)- (-1.68)	1.17	<0.001
(50-59)-(18-29)	-2.24	(-5.41)- (0.93)	1.16	0.300
(60-79)-(18-29)	-3.87	(-7.12)- (-0.61)	1.19	0.011
(40-49)-(30-39)	-2.88	(-6.12)- (0.37)	1.19	0.110
(50-59)-(30-39)	-0.23	(-3.45)- (2.98)	1.18	1.000
(60-79)-(30-39)	-1.86	(-5.16)- (1.45)	1.21	0.540
(50-59)-(40-49)	2.64	(-0.64)- (5.92)	1.20	0.180
(60-79)-(40-49)	1.02	(-2.34)- (4.38)	1.23	0.922
(60-79)-(50-59)	-1.62	(-4.95)- (1.71)	1.22	0.673

Table B.8 Tukey's test results for age-group differences in elbow ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.48	(-3.05)- (2.09)	0.94	0.986
(40-49)-(18-29)	-3.17	(-5.79)- (-0.55)	0.96	0.009
(50-59)-(18-29)	-1.74	(-4.33)- (0.86)	0.95	0.359
(60-79)-(18-29)	-3.62	(-6.29)- (-0.95)	0.98	0.002
(40-49)-(30-39)	-2.69	(-5.35)- (-0.03)	0.97	0.046
(50-59)-(30-39)	-1.26	(-3.89)- (1.38)	0.96	0.690
(60-79)-(30-39)	-3.14	(-5.84)- (-0.44)	0.99	0.013
(50-59)-(40-49)	1.43	(-1.25)- (4.12)	0.98	0.591
(60-79)-(40-49)	-0.45	(-3.21)- (2.30)	1.01	0.992
(60-79)-(50-59)	-1.88	(-4.61)- (0.84)	1.00	0.325

Table B.9 Tukey's test results for age-group differences in fngtip ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.58	(-3.50)- (0.35)	0.71	0.168
(40-49)-(18-29)	-3.53	(-5.50)- (-1.57)	0.72	<0.001
(50-59)-(18-29)	-2.58	(-4.53)- (-0.63)	0.71	0.003
(60-79)-(18-29)	-4.16	(-6.16)- (-2.16)	0.73	0.000
(40-49)-(30-39)	-1.96	(-3.95)- (0.04)	0.73	0.057
(50-59)-(30-39)	-1.00	(-2.97)- (0.97)	0.72	0.637
(60-79)-(30-39)	-2.59	(-4.61)- (-0.56)	0.74	0.005
(50-59)-(40-49)	0.96	(-1.06)- (2.97)	0.74	0.693
(60-79)-(40-49)	-0.63	(-2.70)- (1.44)	0.76	0.921
(60-79)-(50-59)	-1.59	(-3.63)- (0.46)	0.75	0.214

Table B.10. Tukey's test results for age-group differences in th-tip ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.25	(-3.17)- (0.67)	0.70	0.389
(40-49)-(18-29)	-2.99	(-4.95)- (-1.04)	0.72	<0.001
(50-59)-(18-29)	-2.26	(-4.19)- (-0.32)	0.71	0.013
(60-79)-(18-29)	-3.96	(-5.95)- (-1.96)	0.73	<0.001
(40-49)-(30-39)	-1.75	(-3.73)- (0.24)	0.73	0.115
(50-59)-(30-39)	-1.01	(-2.98)- (0.95)	0.72	0.623
(60-79)-(30-39)	-2.71	(-4.73)- (-0.69)	0.74	0.002
(50-59)-(40-49)	0.73	(-1.27)- (2.74)	0.73	0.856
(60-79)-(40-49)	-0.96	(-3.02)- (1.10)	0.75	0.706
(60-79)-(50-59)	-1.70	(-3.74)- (0.34)	0.75	0.154

Table B.11. Tukey's test results for age-group differences in fist ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.80	(-3.86)- (0.26)	0.76	0.119
(40-49)-(18-29)	-3.21	(-5.32)- (-1.11)	0.77	<0.001
(50-59)-(18-29)	-2.41	(-4.49)- (-0.33)	0.76	0.014
(60-79)-(18-29)	-4.17	(-6.31)- (-2.03)	0.78	<0.001
(40-49)-(30-39)	-1.41	(-3.54)- (0.72)	0.78	0.369
(50-59)-(30-39)	-0.61	(-2.72)- (1.50)	0.77	0.933
(60-79)-(30-39)	-2.37	(-4.54)- (-0.20)	0.79	0.024
(50-59)-(40-49)	0.80	(-1.35)- (2.95)	0.79	0.848
(60-79)-(40-49)	-0.96	(-3.17)- (1.25)	0.81	0.760
(60-79)-(50-59)	-1.76	(-3.95)- (0.43)	0.80	0.181

Table B.12. Tukey's test results for age-group differences in waist ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.14	(-2.78)- (2.50)	0.97	1.000
(40-49)-(18-29)	-2.39	(-5.08)- (0.31)	0.99	0.111
(50-59)-(18-29)	-2.03	(-4.70)- (0.64)	0.98	0.229
(60-79)-(18-29)	-4.77	(-7.51)- (-2.03)	1.01	<0.001
(40-49)-(30-39)	-2.24	(-4.98)- (0.49)	1.00	0.164
(50-59)-(30-39)	-1.89	(-4.59)- (0.82)	0.99	0.314
(60-79)-(30-39)	-4.63	(-7.41)- (-1.85)	1.02	<0.001
(50-59)-(40-49)	0.36	(-2.40)- (3.11)	1.01	0.997
(60-79)-(40-49)	-2.38	(-5.21)- (0.45)	1.04	0.146
(60-79)-(50-59)	-2.74	(-5.54)- (0.06)	1.03	0.059

Table B.13. Tukey's test results for job-group differences in waist ht

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	1.98	(0.69)- (3.27)	0.65	0.002

Table B.14. Tukey's test results for BMI-group differences in waist ht

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	-3.05	(-4.34)- (-1.75)	0.66	<0,001

Table B.15. Tukey's test results for age-group differences in vertical grip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.60	(-5.90)- (2.69)	1.57	0.846
(40-49)-(18-29)	-5.70	(-10.09)- (-1.32)	1.61	0.004
(50-59)-(18-29)	-2.40	(-6.74)- (1.93)	1.59	0.555
(60-79)-(18-29)	-7.94	(-12.40)- (-3.48)	1.63	<0.001
(40-49)-(30-39)	-4.10	(-8.54)- (0.34)	1.63	0.087
(50-59)-(30-39)	-0.80	(-5.20)- (3.60)	1.61	0.988
(60-79)-(30-39)	-6.33	(-10.85)- (-1.81)	1.66	0.001
(50-59)-(40-49)	3.30	(-1.19)- (7.79)	1.64	0.262
(60-79)-(40-49)	-2.23	(-6.84)- (2.37)	1.69	0.676
(60-79)-(50-59)	-5.54	(-10.10)- (-0.97)	1.67	0.008

Table B.16. Tukey's test results for age-group differences in vertical th-tip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.75	(-6.09)- (2.59)	1.59	0.807
(40-49)-(18-29)	-5.59	(-10.02)- (-1.16)	1.62	0.005
(50-59)-(18-29)	-2.59	(-6.97)- (1.80)	1.61	0.492
(60-79)-(18-29)	-8.19	(-12.70)- (-3.68)	1.65	<0.001
(40-49)-(30-39)	-3.84	(-8.34)- (0.65)	1.65	0.134
(50-59)-(30-39)	-0.84	(-5.28)- (3.61)	1.63	0.986
(60-79)-(30-39)	-6.44	(-11.01)- (-1.87)	1.67	0.001
(50-59)-(40-49)	3.01	(-1.53)- (7.54)	1.66	0.368
(60-79)-(40-49)	-2.60	(-7.25)- (2.06)	1.71	0.548
(60-79)-(50-59)	-5.60	(-10.22)- (-0.99)	1.69	0.008

Table B.17. Tukey's test results for age-group differences in vertical fngtip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-2.28	(-6.65)- (2.09)	1.60	0.611
(40-49)-(18-29)	-6.05	(-10.52)- (-1.59)	1.64	0.002
(50-59)-(18-29)	-3.28	(-7.69)- (1.14)	1.62	0.254
(60-79)-(18-29)	-8.97	(-13.51)- (-4.43)	1.66	<0.001
(40-49)-(30-39)	-3.77	(-8.29)- (0.75)	1.66	0.153
(50-59)-(30-39)	-0.99	(-5.47)- (3.48)	1.64	0.974
(60-79)-(30-39)	-6.68	(-11.29)- (-2.08)	1.69	0.001
(50-59)-(40-49)	2.78	(-1.79)- (7.34)	1.67	0.459
(60-79)-(40-49)	-2.91	(-7.60)- (1.77)	1.72	0.436
(60-79)-(50-59)	-5.69	(-10.33)- (-1.05)	1.70	0.007

Table B.18. Tukey's test results for BMI-group differences in forward th-tip rch

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.66	(-0.24)- (1.57)	0.46	0.149

Table B.19. Tukey's test results for age-group differences in forward fngtip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.59	(-3.55)- (0.38)	0.72	0.178
(40-49)-(18-29)	-1.99	(-4.00)- (0.02)	0.74	0.053
(50-59)-(18-29)	-0.67	(-2.66)- (1.31)	0.73	0.887
(60-79)-(18-29)	-1.56	(-3.61)- (0.48)	0.75	0.224
(40-49)-(30-39)	-0.41	(-2.44)- (1.63)	0.75	0.983
(50-59)-(30-39)	0.91	(-1.10)- (2.92)	0.74	0.729
(60-79)-(30-39)	0.02	(-2.05)- (2.09)	0.76	1.000
(50-59)-(40-49)	1.32	(-0.74)- (3.37)	0.75	0.402
(60-79)-(40-49)	0.43	(-1.68)- (2.54)	0.77	0.981
(60-79)-(50-59)	-0.89	(-2.98)- (1.20)	0.77	0.772

Table B.20. Tukey's test results for age-group differences in span

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.95	(-4.70)- (2.81)	1.38	0.959
(40-49)-(18-29)	-3.42	(-7.25)- (0.42)	1.40	0.107
(50-59)-(18-29)	-1.81	(-5.60)- (1.98)	1.39	0.689
(60-79)-(18-29)	-5.31	(-9.21)- (-1.41)	1.43	0.002
(40-49)-(30-39)	-2.47	(-6.35)- (1.42)	1.42	0.413
(50-59)-(30-39)	-0.86	(-4.71)- (2.98)	1.41	0.973
(60-79)-(30-39)	-4.36	(-8.32)- (-0.41)	1.45	0.022
(50-59)-(40-49)	1.60	(-2.32)- (5.53)	1.44	0.798

Table B.21. Tukey's test results for age-group differences in elbow-span

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.82	(-3.65)- (2.00)	1.04	0.933
(40-49)-(18-29)	-3.57	(-6.46)- (-0.69)	1.06	0.007
(50-59)-(18-29)	-1.36	(-4.21)- (1.50)	1.05	0.692
(60-79)-(18-29)	-4.40	(-7.34)- (-1.47)	1.08	<0.001
(40-49)-(30-39)	-2.75	(-5.68)- (0.17)	1.07	0.076
(50-59)-(30-39)	-0.54	(-3.43)- (2.36)	1.06	0.987
(60-79)-(30-39)	-3.58	(-6.56)- (-0.61)	1.09	0.009
(50-59)-(40-49)	2.22	(-0.74)- (5.17)	1.08	0.243
(60-79)-(40-49)	-0.83	(-3.86)- (2.20)	1.11	0.945
(60-79)-(50-59)	-3.05	(-6.05)- (-0.04)	1.10	0.045

Table B.22. Tukey's test results for BMI-group differences in chest (bust) depth

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	4.75	(-4.07)- (5.43)	0.35	<0.001

Table B.23. Tukey's test results for age-group differences in chest (bust) depth

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	1.38	(-0.25)- (3.02)	0.60	0.142
(40-49)-(18-29)	2.11	(-0.44)- (3.78)	0.61	0.005
(50-59)-(18-29)	4.22	(-2.57)- (5.87)	0.61	<0.001
(60-79)-(18-29)	4.48	(-2.78)- (6.18)	0.62	<0.001
(40-49)-(30-39)	0.72	(-0.97)- (2.41)	0.62	0.772
(50-59)-(30-39)	2.83	(-1.16)- (4.51)	0.61	<0.001
(60-79)-(30-39)	3.10	(-1.38)- (4.82)	0.63	<0.001
(50-59)-(40-49)	2.11	(-0.40)- (3.82)	0.63	0.007
(60-79)-(40-49)	2.38	(-0.62)- (4.13)	0.64	0.002
(60-79)-(50-59)	0.26	(-1.47)- (2.00)	0.64	0.994

Table B. 24. Tukey's test results for age-group differences in chest (bust) brt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	1.42	(-0.10)- (2.94)	0.56	0.079
(40-49)-(18-29)	2.15	(-0.60)- (3.70)	0.57	0.001
(50-59)-(18-29)	3.85	(-2.32)- (5.39)	0.56	<0.001
(60-79)-(18-29)	4.45	(-2.88)- (6.03)	0.58	<0.001
(40-49)-(30-39)	0.73	(-0.84)- (2.30)	0.58	0.707
(50-59)-(30-39)	2.43	(-0.88)- (3.99)	0.57	<0.001
(60-79)-(30-39)	3.03	(-1.44)- (4.63)	0.59	<0.001
(50-59)-(40-49)	1.70	(-0.12)- (3.29)	0.58	0.028
(60-79)-(40-49)	2.30	(-0.67)- (3.93)	0.60	0.001
(60-79)-(50-59)	0.60	(-1.01)- (2.21)	0.59	0.847

Table B.25. Tukey's test results for job-group differences in chest (bust) brt

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	-1.31	(-2.11)- (-0.50)	0.41	0.001

Table B.26. Tukey's test results for BMI-group differences in chest (bust) brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	4.28	(-3.63)- (4.93)	0.33	<0.001

Table B.27. Tukey's test results for age-group differences in stand e-to-e brt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	3.14	(0.60)- (5.68)	0.93	0.007
(40-49)-(18-29)	4.71	(2.12)- (7.31)	0.95	<0.001
(50-59)-(18-29)	6.28	(3.71)- (8.85)	0.94	<0.001
(60-79)-(18-29)	8.57	(5.92)- (11.21)	0.97	<0.001
(40-49)-(30-39)	1.58	(-1.06)- (4.21)	0.96	0.475
(50-59)-(30-39)	3.14	(0.54)- (5.75)	0.95	0.009
(60-79)-(30-39)	5.43	(2.75)- (8.10)	0.98	<0.001
(50-59)-(40-49)	1.57	(-1.09)- (4.22)	0.97	0.491
(60-79)-(40-49)	3.85	(1.13)- (6.58)	1.00	0.001
(60-79)-(50-59)	2.29	(-0.42)- (4.99)	0.99	0.142

Table B.28. Tukey's test results for BMI-group differences in stand e-to-e brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	6.92	(5.77)- (8.07)	0.58	0.000

Table B.29. Tukey's test results for age-group differences in shld-elbow lgt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.81	(-2.09)- (0.47)	0.47	0.415
(40-49)-(18-29)	-1.51	(-2.82)- (-0.20)	0.48	0.014
(50-59)-(18-29)	0.25	(-1.05)- (1.54)	0.47	0.985
(60-79)-(18-29)	-0.24	(-1.57)- (1.10)	0.49	0.989
(40-49)-(30-39)	-0.70	(-2.02)- (0.63)	0.49	0.607
(50-59)-(30-39)	1.06	(-0.25)- (2.37)	0.48	0.177
(60-79)-(30-39)	0.58	(-0.77)- (1.93)	0.49	0.770
(50-59)-(40-49)	1.76	(0.42)- (3.10)	0.49	0.003
(60-79)-(40-49)	1.27	(-0.10)- (2.65)	0.50	0.085
(60-79)-(50-59)	-0.48	(-1.85)- (0.88)	0.50	0.868

Table B.30. Tukey's test results for age-group differences in foot lgt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.22	(-0.83)- (0.40)	0.23	0.876
(40-49)-(18-29)	-0.44	(-1.07)- (0.19)	0.23	0.307
(50-59)-(18-29)	-0.24	(-0.86)- (0.38)	0.23	0.835
(60-79)-(18-29)	-0.83	(-1.47)- (-0.19)	0.24	0.004
(40-49)-(30-39)	-0.23	(-0.87)- (0.41)	0.23	0.867
(50-59)-(30-39)	-0.02	(-0.65)- (0.61)	0.23	1.000
(60-79)-(30-39)	-0.61	(-1.26)- (0.04)	0.24	0.077
(50-59)-(40-49)	0.20	(-0.44)- (0.85)	0.24	0.909
(60-79)-(40-49)	-0.38	(-1.04)- (0.28)	0.24	0.511
(60-79)-(50-59)	-0.59	(-1.24)- (0.07)	0.24	0.103

Table B.31. Tukey's test results for job-group differences in foot lgt

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	0.42	(0.13)- (0.71)	0.15	0.005

Table B.32. Tukey's test results for BMI-group differences in foot brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.28	(0.13)- (0.44)	0.08	<0.001

Table B.33. Tukey's test results for age-group differences in sit. ht (n)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.14	(-2.17)- (1.90)	0.74	1.000
(40-49)-(18-29)	-2.10	(-4.17)- (-0.02)	0.76	0.046
(50-59)-(18-29)	-2.21	(-4.26)- (-0.16)	0.75	0.027
(60-79)-(18-29)	-3.53	(-5.64)- (-1.42)	0.77	<0.001
(40-49)-(30-39)	-1.96	(-4.06)- (0.14)	0.77	0.081
(50-59)-(30-39)	-2.08	(-4.16)- (0.00)	0.76	0.050
(60-79)-(30-39)	-3.40	(-5.53)- (-1.26)	0.78	<0.001
(50-59)-(40-49)	-0.12	(-2.24)- (2.00)	0.78	1.000
(60-79)-(40-49)	-1.44	(-3.61)- (0.74)	0.80	0.374
(60-79)-(50-59)	-1.32	(-3.48)- (0.84)	0.79	0.453

Table B.34. Tukey's test results for age-group differences in sit. eye ht (n)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.31	(-2.29)- (1.66)	0.73	0.993
(40-49)-(18-29)	-2.38	(-4.40)- (-0.36)	0.74	0.012
(50-59)-(18-29)	-2.30	(-4.29)- (-0.30)	0.73	0.015
(60-79)-(18-29)	-2.97	(-5.02)- (-0.91)	0.75	0.001
(40-49)-(30-39)	-2.06	(-4.11)- (-0.01)	0.75	0.047
(50-59)-(30-39)	-1.98	(-4.01)- (0.05)	0.74	0.059
(60-79)-(30-39)	-2.65	(-4.74)- (-0.57)	0.76	0.005
(50-59)-(40-49)	0.08	(-1.99)- (2.15)	0.76	1.000
(60-79)-(40-49)	-0.59	(-2.72)- (1.53)	0.78	0.941
(60-79)-(50-59)	-0.67	(-2.77)- (1.43)	0.77	0.907

Table B.35. Tukey's test results for age-group differences in sit. elbow rest ht (n)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	0.24	(-1.45)- (1.93)	0.62	0.995
(40-49)-(18-29)	0.08	(-1.64)- (1.81)	0.63	1.000
(50-59)-(18-29)	-0.62	(-2.33)- (1.09)	0.63	0.862
(60-79)-(18-29)	-1.12	(-2.88)- (0.64)	0.64	0.411
(40-49)-(30-39)	-0.16	(-1.91)- (1.59)	0.64	0.999
(50-59)-(30-39)	-0.86	(-2.59)- (0.87)	0.63	0.657
(60-79)-(30-39)	-1.36	(-3.14)- (0.42)	0.65	0.225
(50-59)-(40-49)	-0.70	(-2.47)- (1.07)	0.65	0.816
(60-79)-(40-49)	-1.20	(-3.02)- (0.61)	0.67	0.368
(60-79)-(50-59)	-0.50	(-2.30)- (1.29)	0.66	0.941

Table B.36. Tukey's test results for BMI-group differences in sit. elbow rest ht (n)

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	1.03	(0.12)- (1.95)	0.47	0.026

Table B.37. Tukey's test results for age-group differences in knee ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.80	(-2.09)- (0.49)	0.47	0.443
(40-49)-(18-29)	-1.59	(-2.90)- (-0.27)	0.48	0.009
(50-59)-(18-29)	-0.78	(-2.09)- (0.52)	0.48	0.473
(60-79)-(18-29)	-1.75	(-3.10)- (-0.41)	0.49	0.003
(40-49)-(30-39)	-0.79	(-2.12)- (0.55)	0.49	0.490
(50-59)-(30-39)	0.02	(-1.31)- (1.34)	0.48	1.000
(60-79)-(30-39)	-0.96	(-2.32)- (0.40)	0.50	0.304
(50-59)-(40-49)	0.80	(-0.55)- (2.15)	0.49	0.481

Table B.38. Tukey's test results for job-group differences in knee ht

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	0.68	(0.06)- (1.30)	0.32	0.031

Table B.39. Tukey's test results for age-group differences in popliteal ht

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.23	(-2.21)- (-0.25)	0.36	0.006
(40-49)-(18-29)	-1.65	(-2.65)- (-0.65)	0.37	<0.001
(50-59)-(18-29)	-1.33	(-2.32)- (-0.34)	0.36	0.002
(60-79)-(18-29)	-2.14	(-3.15)- (-1.12)	0.37	<0.001
(40-49)-(30-39)	-0.42	(-1.43)- (0.60)	0.37	0.794
(50-59)-(30-39)	-0.10	(-1.11)- (0.90)	0.37	0.999
(60-79)-(30-39)	-0.91	(-1.94)- (0.13)	0.38	0.115
(50-59)-(40-49)	0.32	(-0.71)- (1.34)	0.38	0.918
(60-79)-(40-49)	-0.49	(-1.54)- (0.56)	0.39	0.709
(60-79)-(50-59)	-0.81	(-1.85)- (0.24)	0.38	0.215

Table B.40. Tukey's test results for BMI-group differences in popliteal ht

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	-1.09	(-1.58)- (-0.60)	0.25	<0.001

Table B.41. Tukey's test results for job-group differences in buttock-knee lgt

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	0.99	(0.19)- (1.78)	0.40	0.014

Table B. 42. Tukey's test results for BMI-group differences in buttock-knee lgt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.53	(-0.30)- (1.35)	0.42	0.207

Table B.43. Tukey's test results for age-group differences in buttock-popliteal lgt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	0.66	(-0.65)- (1.98)	0.48	0.639
(40-49)-(18-29)	-0.06	(-1.40)- (1.27)	0.49	1.000
(50-59)-(18-29)	1.33	(0.01)- (2.66)	0.49	0.048
(60-79)-(18-29)	1.68	(0.32)- (3.04)	0.50	0.007
(40-49)-(30-39)	-0.73	(-2.09)- (0.63)	0.50	0.585
(50-59)-(30-39)	0.67	(-0.68)- (2.01)	0.49	0.656
(60-79)-(30-39)	1.02	(-0.37)- (2.39)	0.51	0.263
(50-59)-(40-49)	1.40	(0.03)- (2.76)	0.50	0.043
(60-79)-(40-49)	1.74	(0.34)- (3.15)	0.52	0.006
(60-79)-(50-59)	0.35	(-1.05)- (1.74)	0.51	0.960

Table B.44. Tukey's test results for BMI-group differences in thigh clearance

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	1.46	(1.11)- (1.81)	0.18	<0.001

Table B.45. Tukey's test results for age-group differences in thigh clearance

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	1.13	(0.34)- (1.92)	0.29	0.001
(40-49)-(18-29)	0.60	(-0.21)- (1.41)	0.30	0.254
(50-59)-(18-29)	0.83	(0.03)- (1.62)	0.29	0.038
(60-79)-(18-29)	0.66	(-0.16)- (1.48)	0.30	0.177
(40-49)-(30-39)	-0.53	(-1.35)- (0.28)	0.30	0.384
(50-59)-(30-39)	-0.31	(-1.11)- (0.50)	0.30	0.841
(60-79)-(30-39)	-0.47	(-1.30)- (0.36)	0.31	0.538
(50-59)-(40-49)	0.23	(-0.60)- (1.05)	0.30	0.944
(60-79)-(40-49)	0.07	(-0.78)- (0.91)	0.31	1.000
(60-79)-(50-59)	-0.16	(-1.00)- (0.68)	0.31	0.984

Table B.46. Tukey's test results for age-group differences in buttock-leg lgt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.77	(-4.20)- (0.66)	0.89	0.272
(40-49)-(18-29)	-3.43	(-5.91)- (-0.95)	0.91	0.002
(50-59)-(18-29)	-1.27	(-3.73)- (1.18)	0.90	0.618
(60-79)-(18-29)	-2.84	(-5.36)- (-0.31)	0.93	0.018
(40-49)-(30-39)	-1.66	(-4.17)- (0.86)	0.92	0.374
(50-59)-(30-39)	0.50	(-1.99)- (2.98)	0.91	0.983
(60-79)-(30-39)	-1.07	(-3.63)- (1.49)	0.94	0.784
(50-59)-(40-49)	2.15	(-0.38)- (4.69)	0.93	0.139
(60-79)-(40-49)	0.59	(-2.02)- (3.19)	0.96	0.973
(60-79)-(50-59)	-1.57	(-4.15)- (1.01)	0.95	0.461

Table B.47. Tukey's test results for age-group differences in sit. vertical grip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.70	(-3.36)- (1.96)	0.98	0.953
(40-49)-(18-29)	-2.44	(-5.16)- (0.27)	1.00	0.101
(50-59)-(18-29)	-0.70	(-3.38)- (1.99)	0.99	0.955
(60-79)-(18-29)	-2.88	(-5.65)- (-0.12)	1.01	0.036
(40-49)-(30-39)	-1.75	(-4.50)- (1.01)	1.01	0.415
(50-59)-(30-39)	0.00	(-2.72)- (2.73)	1.00	1.000
(60-79)-(30-39)	-2.19	(-4.99)- (0.61)	1.03	0.207
(50-59)-(40-49)	1.75	(-1.03)- (4.53)	1.02	0.424
(60-79)-(40-49)	-0.44	(-3.29)- (2.41)	1.05	0.993
(60-79)-(50-59)	-2.19	(-5.01)- (0.64)	1.04	0.215

Table B.48. Tukey's test results for age-group differences in sit. vertical th-tip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.90	(-3.62)- (1.82)	1.00	0.894
(40-49)-(18-29)	-2.84	(-5.61)- (-0.06)	1.02	0.042
(50-59)-(18-29)	-1.06	(-3.80)- (1.69)	1.01	0.831
(60-79)-(18-29)	-3.86	(-6.68)- (-1.03)	1.03	0.002
(40-49)-(30-39)	-1.93	(-4.75)- (0.88)	1.03	0.330
(50-59)-(30-39)	-0.16	(-2.94)- (2.63)	1.02	1.000
(60-79)-(30-39)	-2.96	(-5.82)- (-0.10)	1.05	0.039
(50-59)-(40-49)	1.78	(-1.06)- (4.62)	1.04	0.428
(60-79)-(40-49)	-1.02	(-3.94)- (1.89)	1.07	0.874
(60-79)-(50-59)	-2.80	(-5.69)- (0.09)	1.06	0.062

Table B.49. Tukey's test results for age-group differences in sit. vertical fngtip rch

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-1.06	(-3.74)- (1.62)	0.98	0.817
(40-49)-(18-29)	-3.33	(-6.06)- (-0.60)	1.00	0.008
(50-59)-(18-29)	-1.47	(-4.17)- (1.24)	0.99	0.574
(60-79)-(18-29)	-4.11	(-6.89)- (-1.33)	1.02	0.001
(40-49)-(30-39)	-2.27	(-5.04)- (0.50)	1.01	0.165
(50-59)-(30-39)	-0.41	(-3.15)- (2.33)	1.00	0.994
(60-79)-(30-39)	-3.05	(-5.87)- (-0.24)	1.03	0.026
(50-59)-(40-49)	1.86	(-0.93)- (4.66)	1.02	0.362
(60-79)-(40-49)	-0.78	(-3.65)- (2.09)	1.05	0.947
(60-79)-(50-59)	-2.64	(-5.49)- (0.20)	1.04	0.082

Table B.50. Tukey's test results for BMI-group differences in head circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.49	(0.06)- (0.92)	0.22	0.026

Table B.51. Tukey's test results for BMI-group differences in head brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.18	(-0.01)- (0.37)	0.09	0.059

Table B.52. Tukey's test results for age-group differences in bizygomatic (face) brt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	0.31	(-0.03)- (0.66)	0.13	0.097
(40-49)-(18-29)	0.10	(-0.26)- (0.45)	0.13	0.946
(50-59)-(18-29)	0.41	(0.06)- (0.76)	0.13	0.012
(60-79)-(18-29)	0.54	(0.18)- (0.90)	0.13	<0.001
(40-49)-(30-39)	-0.22	(-0.57)- (0.14)	0.13	0.462
(50-59)-(30-39)	0.10	(-0.26)- (0.45)	0.13	0.946
(60-79)-(30-39)	0.23	(-0.13)- (0.59)	0.13	0.421
(50-59)-(40-49)	0.31	(-0.05)- (0.67)	0.13	0.124
(60-79)-(40-49)	0.44	(0.08)- (0.81)	0.14	0.009
(60-79)-(50-59)	0.13	(-0.23)- (0.50)	0.13	0.861

Table 5.53. Tukey's test results for BMI-group differences in bizygomatic (face) brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.50	(0.34)- (0.67)	0.08	<0.001

Table 5.54. Tukey's test results for age-group differences in neck circumf

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	1.00	(-0.09)- (2.08)	0.40	0.089
(40-49)-(18-29)	1.22	(0.11)- (2.33)	0.41	0.023
(50-59)-(18-29)	2.10	(1.00)- (3.20)	0.40	<0.001
(60-79)-(18-29)	2.58	(1.45)- (3.71)	0.41	<0.001
(40-49)-(30-39)	0.22	(-0.91)- (1.34)	0.41	0.984
(50-59)-(30-39)	1.10	(-0.01)- (2.21)	0.41	0.054
(60-79)-(30-39)	1.58	(0.44)- (2.73)	0.42	0.001
(50-59)-(40-49)	0.88	(-0.25)- (2.02)	0.42	0.212
(60-79)-(40-49)	1.36	(0.20)- (2.53)	0.43	0.012
(60-79)-(50-59)	0.48	(-0.67)- (1.64)	0.42	0.785

Table 5.55. Tukey's test results for BMI-group differences in neck circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	2.84	(2.39)- (3.29)	0.23	<0.001

Table 5.56. Tukey's test results for age-group differences in chest circumf

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	4.66	(-0.44)- (9.77)	1.87	0.092
(40-49)-(18-29)	7.29	(2.08)- (12.50)	1.91	3.820
(50-59)-(18-29)	13.53	(8.37)- (18.68)	1.89	7.160
(60-79)-(18-29)	15.70	(10.4)- (21.00)	1.94	<0.001
(40-49)-(30-39)	2.62	(-2.66)- (7.90)	1.93	0.656
(50-59)-(30-39)	8.86	(3.64)- (14.09)	1.91	4.630
(60-79)-(30-39)	11.03	(5.66)- (16.41)	1.97	5.610
(50-59)-(40-49)	6.24	(0.91)- (11.57)	1.95	3.190
(60-79)-(40-49)	8.41	(2.94)- (13.89)	2.01	4.190
(60-79)-(50-59)	2.17	(-3.25)- (7.59)	1.99	0.810

Table 5.57. Tukey's test results for BMI-group differences in chest circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	15.89	(13.81)- (17.96)	1.05	<0.001

Table 5.58. Tukey's test results for age-group differences in waist circumf

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	6.61	(0.97)- (12.24)	2.06	0.012
(40-49)-(18-29)	8.44	(2.69)- (14.19)	2.11	0.001
(50-59)-(18-29)	16.83	(11.14)- (22.53)	2.09	<0.001
(60-79)-(18-29)	22.27	(16.41)- (28.12)	2.15	<0.001
(40-49)-(30-39)	1.83	(-4.00)- (7.66)	2.14	0.912
(50-59)-(30-39)	10.23	(4.46)- (16.00)	2.11	<0.001
(60-79)-(30-39)	15.66	(9.73)- (21.59)	2.17	<0.001
(50-59)-(40-49)	8.40	(2.51)- (14.28)	2.16	0.001
(60-79)-(40-49)	13.83	(7.79)- (19.87)	2.21	<0.001
(60-79)-(50-59)	5.43	(-0.55)- (11.42)	2.19	0.096

Table B.59. Tukey's test results for job-group differences in waist circumf

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	-5.48	(-8.69)- (-2.26)	1.63	0.001

Table B.60. Tukey's test results for BMI-group differences in waist circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	18.60	(16.15)- (21.05)	1.24	<0.001

Table B.61. Tukey's test results for BMI-group differences in hip brt (sit.)

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	4.29	(3.57)- (5.02)	0.37	<0.001

Table B.62. Tukey's test results for age-group differences in sit. e-to-e brt (n)

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	2.84	(0.40)- (5.29)	0.90	0.013
(40-49)-(18-29)	3.84	(1.34)- (6.34)	0.92	<0.001
(50-59)-(18-29)	5.63	(3.16)- (8.10)	0.91	<0.001
(60-79)-(18-29)	7.93	(5.39)- (10.47)	0.93	<0.001
(40-49)-(30-39)	1.00	(-1.54)- (3.53)	0.93	0.820
(50-59)-(30-39)	2.79	(0.28)- (5.29)	0.92	0.020
(60-79)-(30-39)	5.09	(2.51)- (7.66)	0.94	<0.001
(50-59)-(40-49)	1.79	(-0.76)- (4.35)	0.94	0.309
(60-79)-(40-49)	4.09	(1.47)- (6.71)	0.96	<0.001
(60-79)-(50-59)	2.30	(-0.30)- (4.89)	0.95	0.111

Table B.63. Tukey's test results for BMI-group differences in sit. e-to-e brt (n)

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	6.63	(5.55)- (7.71)	0.55	<0.001

Table B.64. Tukey's test results for BMI-group differences in shld biacr brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.82	(0.17)- (1.48)	0.33	0.013

Table B.56. Tukey's test results for BMI-group differences in shld bideltoid brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	3.60	(2.86)- (4.34)	0.37	<.001

Table B.66. Tukey's test results for BMI-group differences in hand lgt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.20	(-0.05)- (0.45)	0.13	0.110

Table B.67. Tukey's test results for age-group differences in hand brt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	0.18	(-0.08)- (0.43)	0.09	0.327
(40-49)-(18-29)	0.28	(0.02)- (0.54)	0.10	0.028
(50-59)-(18-29)	0.48	(0.22)- (0.74)	0.09	<0.001
(60-79)-(18-29)	0.41	(0.15)- (0.68)	0.10	<0.001
(40-49)-(30-39)	0.10	(-0.16)- (0.37)	0.10	0.821
(50-59)-(30-39)	0.31	(0.04)- (0.57)	0.10	0.012
(60-79)-(30-39)	0.24	(-0.03)- (0.50)	0.10	0.119
(50-59)-(40-49)	0.20	(-0.07)- (0.47)	0.10	0.235
(60-79)-(40-49)	0.13	(-0.14)- (0.41)	0.10	0.687
(60-79)-(50-59)	-0.07	(-0.34)- (0.20)	0.10	0.900

Table B.68. Tukey's test results for BMI-group differences in hand brt

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	0.35	(0.23)- (0.48)	0.06	<0.001

Table B.69. Tukey's test results for job-group differences in hand circumf

Job Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Non-Manual)-(Manual)	-0.49	(-0.77)- (-0.20)	0.15	0.001

Table B.70. Tukey's test results for age-group differences in index finger lgt

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	-0.18	(-0.44)- (0.09)	0.10	0.360
(40-49)-(18-29)	-0.15	(-0.42)- (0.13)	0.10	0.590
(50-59)-(18-29)	-0.06	(-0.33)- (0.21)	0.10	0.973
(60-79)-(18-29)	-0.38	(-0.65)- (-0.10)	0.10	0.002
(40-49)-(30-39)	0.03	(-0.24)- (0.31)	0.10	0.998
(50-59)-(30-39)	0.12	(-0.16)- (0.39)	0.10	0.764
(60-79)-(30-39)	-0.20	(-0.48)- (0.08)	0.10	0.301
(50-59)-(40-49)	0.09	(-0.19)- (0.36)	0.10	0.920

Table B.71. Tukey's test results for BMI-group differences in hand circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	1.11	(0.841)- (1.375)	0.14	<0.001

Table B.72. Tukey's test results for age-group differences in wrist circumf

Age Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(30-39)-(18-29)	0.69	(0.10)- (1.28)	0.22	0.013
(40-49)-(18-29)	0.91	(0.31)- (1.51)	0.22	<0.001
(50-59)-(18-29)	1.21	(0.61)- (1.80)	0.22	<0.001
(60-79)-(18-29)	1.45	(0.84)- (2.07)	0.23	<0.001
(40-49)-(30-39)	0.22	(-0.39)- (0.83)	0.22	0.859
(50-59)-(30-39)	0.52	(-0.08)- (1.12)	0.22	0.129
(60-79)-(30-39)	0.77	(0.14)- (1.39)	0.23	0.007
(50-59)-(40-49)	0.30	(-0.32)- (0.9)	0.23	0.678
(60-79)-(40-49)	0.54	(-0.09)- (1.18)	0.23	0.131
(60-79)-(50-59)	0.25	(-0.38)- (0.88)	0.23	0.824

Table B.73. Tukey's test results for BMI-group differences in wrist circumf

BMI Group Difference	Difference of Means	CI for Means	Standard Error	P-value
(Overweight)-(Normal)	1.45	(1.20)- (1.71)	0.13	<0.001

Table B.80. Regression model table for all other anthropometric measurements.

Anthropometric Variable (Response)	Regression Model with maximized R^2_{adj} value (y as response)
Elbow span	$y = -8.81 + 0.07 \times \text{Body Mass} + 0.54 \times \text{Stature}$ (S=4.16 ; R^2_{adj} = 44.0 %; Cp=4.0)
Chest (bust) depth	$y = 20.0 + 0.21 \times \text{Body Mass} - 0.06 \times \text{Stature} + 0.04 \times \text{Age}$ (S=1.89 ; R^2_{adj} = 71.1%; Cp=4.0)
Standing elbow-to-elbow breadth	$y = 38.9 + 0.28 \times \text{Body Mass} - 0.10 \times \text{Stature} + 0.09 \times \text{Age}$ (S=3.44 ; R^2_{adj} = 62.2%; Cp=4.0)
Shoulder-elbow length	$y = -4.27 + 0.23 \times \text{Stature} + 0.04 \times \text{Age}$ (S=2.04 ; R^2_{adj} = 32.8%; Cp=3.7)
Shoulder-grip axis length	$y = -13.7 + 0.46 \times \text{Stature} + 0.08 \times \text{Age}$ (S=3.17 ; R^2_{adj} = 43.7%; Cp=2.4)
Foot breadth	$y = 4.99 + 0.02 \times \text{Body Mass} + 0.02 \times \text{Stature}$ (S=0.57 ; R^2_{adj} = 18.7%; Cp=2.6)
Sitting eye height (n)	$y = 5.55 + 0.05 \times \text{Body Mass} + 0.43 \times \text{Stature} - 0.03 \times \text{Age}$ (S=2.42 ; R^2_{adj} = 61.6%; Cp=4.0)
Sitting elbow rest height	$y = 11.2 + 0.08 \times \text{Body Mass} + 0.07 \times \text{Stature} - 0.04 \times \text{Age}$ (S=2.99 ; R^2_{adj} = 13.6%; Cp=4.0)
Knee height	$y = 0.70 + 0.03 \times \text{Body Mass} + 0.29 \times \text{Stature}$ (S=1.60 ; R^2_{adj} = 59.5%; Cp=2.0)
Popliteal height	$y = 2.42 - 0.02 \times \text{Body Mass} + 0.24 \times \text{Stature}$ (S=1.26 ; R^2_{adj} = 59.4%; Cp=2.0)
Buttock-knee length	$y = 15.6 + 0.08 \times \text{Body Mass} + 0.22 \times \text{Stature}$ (S=2.62 ; R^2_{adj} = 33.3%; Cp=2.3)
Buttock-popliteal length	$y = 15.0 + 0.03 \times \text{Body Mass} + 0.17 \times \text{Stature} + 0.06 \times \text{Age}$ (S=2.17 ; R^2_{adj} = 27.7%; Cp=4.0)
Thigh Clearance	$y = 8.68 + 0.09 \times \text{Body Mass} - 0.02 \times \text{Age}$ (S=1.12 ; R^2_{adj} = 46.3%; Cp=2.5)
Siting Vertical Grip Reach	$y = 22.8 + 0.07 \times \text{Body Mass} + 0.56 \times \text{Stature}$ (S=3.31 ; R^2_{adj} = 58.1%; Cp=2.5)

Table B.80 Regression model table for all other anthropometric measurements (cont.).

Anthropometric Variable (Response)	Regression Model with maximized R_{adj}^2 value (y as response)
Sitting vertical thumb-tip reach	$y = 19.1 + 0.07 \times \text{Body Mass} + 0.61 \times \text{Stature}$ ($S=3.21$; $R_{adj}^2= 63.3\%$; $C_p=2.1$)
Sitting vertical fingertip reach	$y = 27.8 + 0.05 \times \text{Body Mass} + 0.60 \times \text{Stature}$ ($S=3.34$; $R_{adj}^2= 59.5\%$; $C_p=2.5$)
Sitting forward grip reach	$y = 11.6 + 0.04 \times \text{Body Mass} + 0.31 \times \text{Stature} + 0.05 \times \text{Age}$ ($S=2.66$; $R_{adj}^2= 38.3\%$; $C_p=4.0$)
Sitting forward thumb-tip reach	$y = 10.6 + 0.04 \times \text{Body Mass} + 0.35 \times \text{Stature} + 0.04 \times \text{Age}$ ($S=2.76$; $R_{adj}^2= 40.7\%$; $C_p=4.0$)
Sitting forward fingertip reach	$y = 13.0 + 0.05 \times \text{Body Mass} + 0.37 \times \text{Stature} + 0.03 \times \text{Age}$ ($S=2.90$; $R_{adj}^2= 42.1\%$; $C_p=2.4$)
Head length	$y = 12.7 + 0.01 \times \text{Body Mass} + 0.03 \times \text{Stature}$ ($S=0.82$; $R_{adj}^2= 8.2\%$; $C_p=2.2$)
Head breadth	$y = 14.2 + 0.01 \times \text{Body Mass}$ ($S=0.71$; $R_{adj}^2= 4.7\%$; $C_p=2.6$)
Menton-sellion (face) length	$y = 7.77 + 0.01 \times \text{Body Mass} + 0.02 \times \text{Stature}$ ($S=0.82$; $R_{adj}^2= 5.3\%$; $C_p=3.8$)
Bizygomatic (face) breadth	$y = 10.8 + 0.03 \times \text{Body Mass}$ ($S=0.56$; $R_{adj}^2= 31.0\%$; $C_p=3.2$)
Neck circumference	$y = 24.0 + 0.02 \times \text{Age} + 0.13 \times \text{Body Mass}$ ($S=1.32$; $R_{adj}^2= 64.8\%$; $C_p=2.0$)
Chest circumference	$y = 86.2 + 0.13 \times \text{Age} + 0.72 \times \text{Body Mass} - 0.27 \times \text{Stature}$ ($S=4.60$; $R_{adj}^2= 83.1\%$; $C_p=4.0$)
Hip breadth (sitting)	$y = 23.9 + 0.21 \times \text{Body Mass}$ ($S=2.20$; $R_{adj}^2= 60.8\%$; $C_p=1.7$)
Sitting elbow-to elbow breadth (n)	$y = 23.4 + 0.09 \times \text{Age} + 0.28 \times \text{Body Mass}$ ($S=3.20$; $R_{adj}^2= 63.7\%$; $C_p=4.0$)
Shoulder biacromial breadth	$y = 14.6 + 0.05 \times \text{Body Mass} + 0.11 \times \text{Stature}$ ($S=2.38$; $R_{adj}^2= 15.4\%$; $C_p=3.2$)

Table B.80 Regression model table for all other anthropometric measurements (cont.).

Anthropometric Variable (Response)	Regression Model with maximized R_{adj}^2 value (y as response)
Hand breadth	$y = 4.31 + 0.01x_{\text{Age}} + 0.01x_{\text{Body Mass}} + 0.02x_{\text{Stature}}$ ($S=0.44$; $R_{adj}^2= 25.5\%$; $C_p=4.0$)
Palm length perpendicular	$y = 1.33 + 0.01x_{\text{Age}} + 0.01x_{\text{Body Mass}} + 0.05x_{\text{Stature}}$ ($S=0.53$; $R_{adj}^2= 28.2\%$; $C_p=4.0$)
Index finger length	$y = 2.23 + 0.01x_{\text{Body Mass}} + 0.03x_{\text{Stature}}$ ($S=0.48$; $R_{adj}^2= 14.8\%$; $C_p=4.0$)
Hand circumference	$y = 12.6 + 0.04x_{\text{Body Mass}} + 0.02x_{\text{Stature}} + 0.02x_{\text{Age}}$ ($S=0.93$; $R_{adj}^2= 37.4\%$; $C_p=4.0$)
Wrist circumference	$y = 11.4 + 0.06x_{\text{Body Mass}} + 0.01x_{\text{Age}}$ ($S=0.82$; $R_{adj}^2= 54.2\%$; $C_p=2.6$)

B.3 Pilot Study

Table B.81. Required Sample size for each measurement

	$\bar{x}(s)$	CV	N
Body mass (kg)	66.72 (13.37)	20.04	145.20
Stature (e)	156.23 (6.55)	4.19	6.36
Stature (n)	155.88 (6.43)	4.12	6.15
Eye ht (e)	145.85 (6.57)	4.50	7.34
Eye ht (n)	145.08 (6.53)	4.50	7.33
Acr. (shld) ht (e)	131.45 (5.8)	4.41	7.04
Acr. (shld) ht (n)	130.48 (6)	4.60	7.65
Elbow ht (n)	95.52 (5.4)	5.65	11.56
Fngtip ht (n)	58.78 (3.72)	6.33	14.48
Th-tip ht (n)	64.72 (3.77)	5.83	12.27
Knuckle ht (n)	69.24 (4.01)	5.79	12.13
Waist ht (n)	89.2 (5.18)	5.81	12.19
Vertical grip rch	185.54 (8.06)	4.34	6.82
Vertical th-tip rch	190.34 (8.11)	4.26	6.56
Vertical fngtip rch	195.52 (8.16)	4.17	6.30
Forward grip rch	64.56 (3.14)	4.86	8.55
Forward th-tip rch	68.98 (3.59)	5.20	9.79
Forward fngtip rch	74.69 (3.73)	4.99	9.02
Span	154.87 (7.99)	5.16	9.62
Elbow span	79.49 (5.26)	6.62	15.83
Chest (bust) depth	25.94 (3.49)	13.45	65.45
Chest (bust) brt	28.04 (3.39)	12.09	52.85
Stand. e-to-e brt	46.41 (5.55)	11.96	51.71
Shld-elbow lgt	34.44 (2.8)	8.13	23.90
Shld-fngtip lgt	71.71 (4.4)	6.14	13.61
Shld-fist lgt	61.29 (4.47)	7.29	19.23
Foot lgt	23.21 (1.18)	5.08	9.35
Foot brt	9.08 (0.57)	6.28	14.25
Sit. ht(e)	84.86 (3.89)	4.58	7.60
Sit. ht (n)	84.1 (4.07)	4.84	8.47
Sit. eye ht (e)	74.46 (3.92)	5.26	10.02
Sit. eye ht (n)	73.67 (3.83)	5.20	9.77
Sit. acr. (shld) ht (e)	60.31 (3.49)	5.79	12.11
Sit. acr. (shld) ht (n)	59.17 (3.51)	5.93	12.72
Sit. elbow rest ht (n)	26.01 (3.26)	12.53	56.80
Knee ht	47.1 (2.36)	5.01	9.08
Popliteal ht	37.87 (1.95)	5.15	9.59
Buttock-knee lgt	55.67 (2.97)	5.34	10.29
Buttock-popliteal lgt	46.9 (2.43)	5.18	9.71
Thigh clearance	13.73 (1.54)	11.22	45.49
Buttock-Leg Lgt	94.49 (4.34)	4.59	7.63
Sit.vertical grip rch	115.65 (5.19)	4.49	7.28
Sit.vertical th-tip rch	119.27 (5.34)	4.48	7.25
Sit.vertical fngtip rch	124.49 (5.3)	4.26	6.55
Sit.forward grip rch	65.51 (3.22)	4.92	8.74

Table B.81 Required Sample size for each measurement (cont.).

	$\bar{x}(s)$	CV	N
Sit.forward th-tip rch	69.53 (3.43)	4.93	8.80
Sit.forward fngtip rch	75.14 (3.6)	4.79	8.30
Head circumf	55.25 (1.67)	3.02	3.30
Head lgt	17.84 (0.81)	4.54	7.45
Head brt	15.01 (0.64)	4.26	6.57
Ment-sellion (face) lgt	11.72 (0.72)	6.14	13.65
Bizygomatic (face) brt	12.75 (0.6)	4.71	8.01
Neck circumf	33.51 (2.18)	6.51	15.30
Chest circumf	97.15 (11.48)	11.82	50.49
Waist circumf	86.82 (12.97)	14.94	80.70
Hip brt (sit.)	38.12 (3.74)	9.81	34.81
Sit. e-to-e brt (n)	46.11 (5.38)	11.67	49.23
Shld biacr. brt	35.21 (2.55)	7.24	18.97
Shld bideltoid brt	41.73 (3.37)	8.08	23.58
Hand lgt	17.09 (1.04)	6.09	13.39
Hand brt	7.98 (0.47)	5.89	12.54
Palm lgt perp	9.54 (0.63)	6.60	15.77
Index finger lgt	6.97 (0.59)	8.46	25.91
Hand circumf	19.57 (1.16)	5.93	12.70
Wrist circumf	16.2 (1.1)	6.79	16.67