# Anthropometric indices in relation to overweight and obesity among Turkish medical students

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## Abstract

**Introduction:** The aim of this study was to present the reference anthropometric data associated with obesity for cardiovascular risk and metabolic diseases for healthy young adults in a Turkish population.
**Material and methods:** The study group consisted of 1163 second-year medical students (650 women, 513 men) aged 20-25 years from Çukurova University in Adana and the measurements were made using a flexible standard measuring tape. The data were collected during the period 2007-2011.
**Results:** From 1163 medical students, the mean values of body mass index, circumferences of waist, hip, neck, mid-arm, thigh and calf were 20.89 ±1.6 kg/m$^2$, 73.15 ±5.1 cm, 95.35 ±4.8 cm, 30.32 ±1.37 cm, 24.12 ±1.75 cm, 47.23 ±3.26 cm and 34.36 ±2.19 cm respectively in women, while the same measurements were 21.98 ±1.67 kg/m$^2$, 77.73 ±5.81 cm, 95.64 ±4.81 cm, 35.61 ±1.43 cm, 25.60 ±1.84 cm, 44.10 ±3.26 cm and 34.92 ±2.08 cm respectively in men. Moreover, waist to hip ratio, waist to height ratio and neck to height ratio were respectively 0.76, 0.44 and 0.18 in women and 0.81, 0.43 and 0.19 in men.
**Conclusions:** The precise knowledge of anthropometric data could be used as reference values for evaluating the body composition and fat distribution of Turkish young people.

**Key words:** anthropometry, body mass index, circumference measurements, obesity.

## Introduction

Obesity is a rapidly growing health problem throughout the world and is defined as a body mass index (BMI) 30 kg/m$^2$ or higher. Obesity and body fat distribution are important predictors of coronary heart disease [1, 2]. Moreover, they are associated with several chronic diseases including hyperlipidemia, hyperinsulinemia and hypertension [2-5]. From a clinical view, estimation of adipose tissue distribution must therefore be considered as important in the evaluation of the patient's cardiovascular risk profile [6]. There are numerous methods of assessing overweight, obesity and fat distribution such as measurements of weight, height, waist, hip, midarm, thigh and calf circumferences and calculations of waist-to-hip ratio, and BMI. For many years, the waist-hip ratio (WHR) was used for evaluation of the body fat distribution. But in some studies, it was reported that waist circumference is more closely associated with the central fat distribution than WHR [6, 7]. Recently, another anthropometric index, waist-to-height ratio (WHtR), was shown to be better correlated with metabolic risk factors [8-10]. Nevertheless, the best method for evaluation of the fat distribution is computed tomography. However, computed tomog-

raphy (CT) is impractical as a routine method for measuring because of radiation exposure and high cost [6, 11-14]. Therefore, a practical alternative to CT and magnetic resonance imaging (MRI) is anthropometry. Instruments for measuring the anthropometric dimensions are portable and inexpensive, and procedures are noninvasive and easily applied. Although obesity results in metabolic abnormalities, upper-body obesity is more strongly associated with some pathologies, such as glucose intolerance, diabetes mellitus and gout, than lower-body obesity. Moreover, in a previous study, neck circumference as an index of upper-body obesity was found to be a simple measure that can be used to identify overweight and obese people. It was also shown that large neck circumference correlated with blood pressure [15].

The aim of the present study was therefore to identify reference anthropometric indices related to cardiovascular risks and metabolic diseases in healthy women and men in a Turkish group and compare them with other populations.

## Material and methods

The study group consisted of 1163 (650 women, 513 men) second-year medical students aged 20-25 years in the Çukurova University, School of Medicine during the period 2007-2011. The study was approved by the ethics committee of the School of Medicine, Çukurova University. A questionnaire form was prepared. The basis of this questionnaire was to obtain the medical history of the study group. It included biographical data, lifestyle behaviors such as cigarette smoking and alcohol use, and medical history of cardiovascular diseases, high blood pressure, and diabetes mellitus. Weight was measured with electronic scales to the nearest 0.1 kg wearing minimal clothing without shoes and height was measured to the nearest millimeter in bare feet with a wall-mounted stadiometer. Then body mass index (BMI; in kg/m$^2$) was calculated. Circumference measurements were made with a flexible standard measuring tape in the plane orthogonal to the long axis of the body segment being measured. Waist circumference (WC) was measured midway between the lowest rib and top of the iliac crest at the end of gentle expiration. Hip circumference (HC) was evaluated at the maximum protuberance of the buttocks. Moreover, circumferences at the mid-arm (AC), mid-thigh (TC) and calf (CC) were recorded. Neck circumference (NC) was measured in the middle of the neck between the mid-cervical spine and mid-anterior neck. However, in men with a laryngeal prominence, it was measured just below the prominence. Since taller people are expected to have a larger neck, it is normalized by calculating the neck/height ratio. After these measurements waist-to-hip ratio and waist-to-height ratio were also calculated.

The data were divided into two groups according to gender and statistical analysis was performed with SPSS 10.0. From these measurements, means, standard deviations, and minimum and maximum values were evaluated.

## Results

The baseline characteristics of the 650 women and 513 men are shown in Table I. When we analyzed the data in this study, from the questionnaire, it was found that nobody had a history of cardiovascular or other diseases in both genders. From 513 men, 106 (20.66%) smoked cigarettes and 60 (11.69%) used alcohol, while in women, 70 (10.76%) of 650 used cigarettes and 20 (3.1%) of them used alcohol. No significant differences were found between the anthropometric indices of smokers and non-smokers. Additionally, from our measurements, the mean age, HC, CC and WHtR levels were similar in women and men among the medical students. Compared to women, men were heavier, taller, and had higher WC, NC, AC, TC and WHR (Table I). The mean values of BMI were 20.89 kg/m$^2$ in women and 21.98 kg/m$^2$ in men. The mean values of the circumferences of waist, hip, arm, thigh, calf and neck were 73.15 ±5.1 cm, 95.35 ±4.8 cm, 24.12 ±1.7 cm, 47.23 ±3.3 cm, 34.36 ±2.2 cm and 30.32 ±1.4 cm respectively in women, and 77.73 ±5.8 cm, 95.64 ±4.8 cm, 25.6 ±1.8 cm, 44.1 ±3.3 cm, 34.92 ±2.1 cm and 35.61 ±1.4 cm respectively in men. Finally, the means of the ratios of waist-hip, waist-height and neck-height were estimated as 0.76, 0.44 and 0.18 respectively in women, and 0.81, 0.43 and 0.19 respectively in men.

## Discussion

The present study provides a summary of anthropometric values related to cardiovascular risks and metabolic disorders in healthy young Turkish people and compares them with other populations.

Based on the meeting of the International Obesity Task Force, a BMI of 18.5-24.9 kg/m$^2$ is defined as the optimal range, BMI of 25 to 29.9 kg/m$^2$ is defined as overweight, and BMI $\geq$ 30 kg/m$^2$ is defined as obese. Conversely, BMI $\leq$ 18.5 kg/m$^2$ is defined as underweight [16-18]. Obesity is associated with several risk factors for heart disease and other chronic diseases including hyperlipidemia, hyperinsulinemia, hypertension and atherosclerosis [2]. Unfortunately, the prevalence and incidence of obesity are increasing rapidly in both developed and developing countries [2, 14, 19, 20]. Because of public health importance, the trends in young adult obesity should be monitored. In literature findings, there were mean values of weight and height of study groups from different countries. But the BMI (kg/m$^2$) is widely used in definition of adult obesity. Addi-

**Table I.** Anthropometric indices of healthy women and men

| Anthropometric index | Sex | Mean ± standard deviation | Minimum-maximum |
|---|---|---|---|
| Age [years] | Women | 21.41 ±0.9 | 20-25 |
| | Men | 21.69 ±1.27 | 20-25 |
| Height [cm] | Women | 164.86 ±4.8 | 156-178 |
| | Men | 178.63 ±5.3 | 165-188 |
| Weight [kg] | Women | 56.8 ±5.0 | 47-68 |
| | Men | 70.2 ±6.78 | 54-85 |
| BMI [kg/m$^2$] | Women | 20.89 ±1.6 | 18.6-24.6 |
| | Men | 21.98 ±1.67 | 18.6-24.9 |
| WC [cm] | Women | 73.15 ±5.1 | 60-85 |
| | Men | 77.73 ±5.81 | 67-91 |
| HC [cm] | Women | 95.35 ±4.8 | 87-113 |
| | Men | 95.64 ±4.81 | 86-105 |
| NC [cm] | Women | 30.32 ±1.37 | 28-33 |
| | Men | 35.61 ±1.43 | 33-39 |
| AC [cm] | Women | 24.12 ±1.75 | 21-28 |
| | Men | 25.6 ±1.84 | 22-31 |
| TC [cm] | Women | 47.23 ±3.26 | 40-58 |
| | Men | 44.1 ±3.26 | 37-50 |
| CC [cm] | Women | 34.36 ±2.19 | 30-40 |
| | Men | 34.92 ±2.08 | 30-41 |
| WHR | Women | 0.76 ±4.187E | 0.69-0.85 |
| | Men | 0.81 ±3.928E | 0.73-0.93 |
| WHtR | Women | 0.44 ±3.106E | 0.38-0.52 |
| | Men | 0.43 ±2.893E | 0.37-0.49 |

*BMI – body mass index, WC – waist circumference, HC – hip circumference, NC – neck circumference, AC –arm circumference, TC – thigh circumference, CC – calf circumference, WHR – waist-to-hip circumference ratio, WHtR – waist-to-height ratio*

tionally, obesity raises surgical morbidity and mortality because of its adverse effects on cardiopulmonary dynamics, wound healing and sedation or anesthesia [21]. In a study including Greek medical students, a high proportion of subjects were overweight (27.6%) or obese (4.3%) [16]. A study in Slovakia reported that 16% of male and 2% of female medical students had a BMI > 25.0 kg/m$^2$ [22]. Moreover, an investigation conducted among 154 medical students in South Africa estimated the rates of overweight and obesity as 8.9% and 2.5% respectively for Indian and 19.7% and 4.6% for black students [23]. In this paper, we document the values of healthy students so both underweight and overweight subjects' anthropometric indices are excluded in this investigation.

For health promotion, waist circumference is becoming preferred for determination of adiposity since this measurement reflects total and abdominal fat accumulation [14, 20, 24]. So this anthropometric variable is used more often to identify risk of cardiovascular diseases and metabolic disorders than BMI [25, 26]. It was emphasized that waist circumferences greater than 102 cm in men and greater than 88 cm in women had a strong correlation with development of several disorders including hypercholesterolemia and hypertension [24]. In addition, waist-to-hip ratio and waist-to-height ratio were widely used for evaluating the regional adipose tissue [6]. However, several researchers have indicated that the waist circumference alone is more closely correlated with the level of abdominal adipose tissue than the WHR [6, 27]. Conversely, it was noted that waist-to-height ratio was the best simple anthropometric predictor of abdominal fat in previous reports [8, 28]. Also it was suggested that the boundary value for risk (WHtR-0.5) might be used for both women and men [8, 10, 29]. Ashwell *et al*. reported that the boundary value of WHtR translated into a simple public health message: "Keep your waist circumference to less than half your height" [8]. Furthermore, it was observed

that WC in women and WHtR in men were strong indicators for abnormal serum lipids and lipoproteins [16]. In this study, the mean values of waist circumference, waist-to-hip ratio, and waist-to-height ratio were 73.15 ±5.1 cm, 0.76 and 0.44 respectively in women, whereas the same indices were 77.73 ±5.81 cm, 0.81 and 0.43 respectively in men. In a study including Chinese people, these values were 77.3 ±9.4 cm, 0.84, 0,50 respectively in women and 83.3 ±8.3 cm, 0.90, 0.50 respectively in men [30]. In Indians, the mean values of WC and WHR were estimated as 77.4 ±12.6 cm, 0.82 respectively in women and 79.6 ±11.4 cm, 0.86 in men [31]. In 21-year-old Dutch people, the same indices were 71.3 cm and 0.75 in women and 79.6 cm and 0.83 in men respectively [7]. Hill *et al*. reported these values as 86.6 cm, 0.79 in black women and as 76.1 cm, 0.74 in white women respectively, while in black men they were 87.6 cm, 0.84 and in white men 89.2 cm, 0.87 [13]. According to these values, we found differences in all mean values of Chinese, Indians, and Hill's study group (blacks and whites) compared with our results, having greater values than us. However, Dutch people's mean values are similar to our indices.

Body composition exhibits consistent and substantial change with age. Among the age-related patterns are a decrease in fat-free mass, especially skeletal muscle, an increase in overall adiposity and accumulation of adipose tissue at the middle body. Regarding body changes, age-related loss of muscle mass beginning after early adulthood is reported [32]. Calf circumference is emphasized to be a helpful indicator of fat-free mass and is considered a good indicator of undernourishment [25, 32]. Furthermore, mid-thigh circumference is also used for lean body weight [32]. When we analyzed our anthropometric indices, the mean values of circumferences of arm, thigh and calf were 24.12 cm, 47.23 cm, 34.36 cm in women and 25.6 cm, 44.1 cm, 34.9 cm in men respectively. These circumferences were 27.1 cm, 53.8 cm, 35.7 cm in women and 28.5 cm, 53.1 cm, 36.3 cm in men from the Free University of Brussels [33]. Also, in a study including four racial groups (African American, Asian, white and Hispanic), the same dimensions were reported as 28.9 cm, 53.8 cm, 35.7 cm in women and 32.4 cm, 55.3 cm, 37.8 cm in men respectively [12]. Differences between circumferences in this study and those of Portman's and Lee's in Brussels, Canada and New York may be explained by socioeconomic and lifestyle differences.

Upper-body obesity is more strongly associated with glucose intolerance, hyperinsulinemia, diabetes, and gout than is lower-body obesity [15]. Neck circumference is determined as an index of upper-body subcutaneous adipose tissue distribution and is related to cardiovascular risk factors. Thus, it was indicated that NC can be used as a simple, easy test to identify overweight or obese patients. Furthermore, measurement of NC has become a part of the physical examination of patients with sleep apnea [34]. It was reported that obesity is believed to predispose to sleep apnea because of mass loading of the upper airway by adipose tissue in the neck [35]. In this study, the mean value of NC was 30.32 cm in women and 35.61 cm in men. We found a highly significant difference in this circumference between genders. In literature findings, men had higher values than women as in our report but their mean values were greater than ours [15, 34].

In summary, we observe that there are differences between the anthropometric indices of other populations including Chinese, Indian, African American and Hispanic and our population. However, there are some similar values in some indices in Dutch people and in our group. We think that this diversity could depend on several factors such as genetic variables, race, nutritional status, different socioeconomic-cultural characteristics and also lifestyle differences.

The World Health Organization (WHO) emphasizes the need for population-specific reference values. Furthermore, since adipose tissue has different distributions in women and men, the data should be presented as gender-specific means with standard deviations for each index [25]. Genetic, environmental and ethnic factors can all influence the degree of risks associated with excess body weight. Given the health cost implications of diseases such as diabetes mellitus, hypertension, dyslipidemia, coronary heart disease and cancer, which are closely associated with overweight/obesity, these data will facilitate the development of a preventive strategy for these health care problems. Thus, young adults who are identified as being at high risk of excess adiposity could be encouraged to make lifestyle changes, such as increased physical activity, and be given nutrition education and dietary counseling [11]. Moreover, body composition is commonly investigated in epidemiological, clinical and population studies. Reliable methods for measurement of body fat and fat distribution are therefore important and anthropometry is the most widely used method. The distinct advantages of anthropometry, which we used in this paper, are that it is portable, non-invasive and inexpensive.

In conclusion, we think that precise knowledge concerning the anthropometric indices of healthy young adults correlated with cardiac and metabolic pathologies could be essential for determining public health and providing reference data and can be used as reference values for evaluating the body composition and fat distribution of young Turkish people. As a result, we believe that the data presented in this study will provide useful references for clinical practice and epidemiological studies for assessment of obesity.

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