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Use of knee height for the estimation of stature in elderly Turkish people and their relationship with cardiometabolic risk factors

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ABSTRACT

The determination of the approximately truest value in height measurement is important in many fields, but it is difficult to perform true measurements, especially in the elderly individuals. We planned to investigate the following items in geriatric Turkish population: to calculate the decrease in height with advancing age by using the standing height measurement and estimated height derived from the knee height; to evaluate the significance of difference between the two measurement methods in the calculation of body mass index (BMI) and waist/height ratio (WHtR); to determine the cut-off value of WHtR according to estimated height in elderly individuals. We studied 551 cases aged between 19 and 97 years. Knee height was measured using a sliding caliper in a sitting position. Linear regression analysis was carried out to derive predictive equations for the estimation of stature with adults ($\leq$50 years of age) according to the gender. This equation was then used to estimate height among elderly subjects. Of the cases, 60.3% were <60 years (mean: 48.75 $\pm$ 7.50); 39.7% of the cases were >60 years (mean: 69.51 $\pm$ 7.12). 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. EBMI measurements in the females <60 years were 0.32 kg/m^2 higher than their real BMIs ($p < 0.01$). There is a statistically significant difference between WHtR in the females of both age groups, and in the males >60 years, as compared to our estimated WHtR (EWHtR) measurements ($p < 0.01$). The cut-off point of WHtR was 0.61 and 0.58 in the female and male cases of >60 years in our study, respectively. WHtR seemed to be a better anthropometric index that could predict most cardiometabolic risk factors in our study. EWHtR emerged to be a better cardiometabolic risk index especially in the elderly group.

1. Introduction

Obesity is becoming an epidemic health problem worldwide including the developing countries. Anthropometric indices represent a simple, safe and cost-free way to quantify the degree of obesity. BMI is a widely used indicator of possible health risk and increasing BMI has been related to health risks and death rates in many studies (WHO, 2000; Woo et al., 2002). However, the waist circumference (WC) has been criticized for not taking into account differences in body height and the WHtR has been proposed as a better predictor of cardiovascular risk (Ashwell et al., 1996; Schneider et al., 2005), mortality (Cox and Whichelow, 1996) and intra-abdominal fat.

It was shown in a recent study conducted within a large cohort of primary care patients from the DETECT study (Schneider et al., 2007) that the WHtR predicted point prevalence of CAD, type 2 diabetes and dyslipidemia, as assessed by physicians' records, better than other measures of obesity.

But height measurement is seen to have a leading role in the calculation of these anthropometric parameters. The determination of the approximately truest value in height measurement is important in many fields (calculation of body surface for various treatments, BMI, calculation of creatinine clearance, calculation of energy need, determination of reference body weight, determination of WHtR). Anthropometric measurements are also valuable in detailed evaluation of the nutritional status. But performing exact measurements is especially more difficult in elderly individuals. It is especially difficult or even impossible to measure height in elderly individuals, bed-bound people, individuals with contracture, people with advanced arthritis, paralytic conditions or amputations. The height decreases with advancing age. This may occur due to deformity and incorrect postural habits in knees due to arthritis, postural changes, reduced muscle tone or loss of muscle tone and vertebral compressions developing especially secondary to osteoporosis (Bağci Bosi, 2003). Aging is associated with several physiological, psychological and biological changes,

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including body composition, such as an increase in body fat and a decrease in lean body mass and also in bone mass (Kuczmarski, 1989). This can lead to changes in body posture and thinning of the vertebral discs which can contribute to a reduction in height (Prothro and Rosenbloom, 1993) or even kyphosis in elderly people with osteoporosis (Roubenoff and Wilson, 1993). Therefore, a simple and reliable measure of height is especially necessary in elderly people (Eveleth et al., 1998). Since the length of long bones in the arms and legs does not reduce with age, armspan and knee height have been used as indirect measures of height in elderly people. Knee height would seem to be the preferred measurement, since it is not affected by height loss resulting from vertebral compression (Cheng et al., 2001; Pini et al., 2001). Armspan has also been used, but may be less satisfactory than knee height because of joint stiffness in older people, which could reduce the accuracy of the measurement (Han and Lean, 1996).

In our study, we planned to investigate the following items in geriatric Turkish population: to calculate the decrease in height with advancing age by using direct height measurement and estimated height derived from knee height; to evaluate the significance of difference between two measurement methods in the calculation of BMI and WHtR. Additionally, we planned to determine the correlations between cardiometabolic risk factors and anthropometric indices like WHtR and BMI measured using height derived from knee height and WHtR and BMI calculated with direct height measurement. And we calculated the cut-off value of WHtR calculated using height derived from knee height measurement in elderly individuals.

2. Subjects and methods

2.1. Subjects

The subjects were 551 patients who underwent health examinations at Sisli Etfal Training and Research Hospital between May 2009 and December 2009. Their ages varied between 19 and 97 years (57.02 ± 12.55) at the time of the examination; most of them were government employees or members of their families. Questionnaire data on demography, history of medical illness and medication use was filled out using a clinical interview. Apart from age, the exclusion criteria for subjects included those with amputated limbs, kyphosis, edema or dehydration, taking diuretic drugs and insulin. Pregnant women were also excluded from the study.

This study was conducted in accordance with the guidelines proposed in the Declaration of Helsinki and has been approved by the local ethical committee. All subjects gave informed consent before the study initiated.

2.2. Health examination survey

Height and weight data were obtained using standardized techniques and equipment. Standing height was measured using a stadiometer. Heights were measured while the subjects were wearing no shoes, hair coverings or hair bands and with hair smoothed down. The subjects stood with arms at their sides looking straight ahead, breathing normally, feet flat, legs straight, with knees together and heels together. Shoulder blades, buttocks and heels touched the measuring board. Measurements were recorded to the nearest 0.1 cm. BMI was calculated by dividing weight by height squared (kg/m^2). Using a fiberglass tape measure, the WC was measured at the midpoint between the bottom of the rib cage and the top of the iliac crest. Measurement was made with a participant standing erect, abdomen relaxed, arms at the sides and feet together with weight equally divided over both legs. WHtR was calculated as WC divided by height. After 5 min of rest while seated, blood pressure was measured 3 times with 30-s intervals using a standard mercury sphygmomanometer. The average of the 2nd and 3rd measurements was used in the analysis. Blood samples were collected in the morning after fasting for at least 8 h. FBG, total cholesterol (TC), triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), urea, and creatinine levels were measured in central laboratory of our hospital.

FBG, TC, HDL, LDL, TG, urea and creatinine were measured through the end-point colorimetric method.

Insulin resistance was estimated with the homeostasis model assessment insulin resistance index (HOMA-IR), calculated from the equation (Matthews et al., 1985):

$$\text{HOMA-IR} = [\text{fasting serum insulin}\,(\text{mU/ml}) \times \text{FBG}\,(\text{mmol/l})] = 22.5$$

2.3. Definition of cardiovascular disease (CVD) risk factors

In the present study, we used the definitions of cardiometabolic risk factors proposed by the NCEP (2001). The cut-off points were plasma TC $\geq$ 240 mg/dl for high TC and/or use of medications to lower blood cholesterol, serum TG $\geq$ 150 mg/dl, HDL-C $<$ 50 mg/dl for women and HDL-C $<$ 40 mg/dl for men and LDL-C $\geq$ 160 mg/dl and/or use medications to lower blood cholesterol for high LDL-C. Patients with FBG $\geq$ 126 mg/dl and or physician-diagnosed diabetes mellitus and/or use oral hypoglycemic agent were defined as having diabetes mellitus. Hypertension was defined as a systolic blood pressure (SBP) $\geq$ 140 mmHg or diastolic blood pressure (DBP) $\geq$ 90 mmHg and/or physician-diagnosed hypertension and/or use antihypertensive medication. Components of the metabolic syndrome were defined according to the modified NCEP Adult Treatment Panel III criteria. The metabolic syndrome score (MSS) was calculated as the sum of the following positive components, excluding WC: (1) SBP $\geq$ 130 mmHg or DBP $\geq$ 85 mmHg, (2) TG $\geq$ 150 mg/dl, (3) HDL-C $<$ 50 mg/dl for women and $<$40 mg/dl for men and (4) FBG $\geq$ 100 mg/dl. Subjects on drug therapy for hypertension, hyperglycemia or hypertriglyceridemia and low HDL-C levels were also assigned to positive components (NCEP, 2001; Grundy et al., 2005). Subjects, who had one or more metabolic syndrome components, excluding WC, were classified as MSS $\geq$ 2.

2.4. Knee height

Knee height was measured using a sliding caliper (Tanita, Harpenden Anthropometer) in a sitting position. Measurements were taken on the left leg by positioning the knee and ankle at a 90° angle. The fixed blade of the caliper was held parallel to the shaft of the tibia and the moveable blade was positioned parallel to the fibula over the lateral malleolus and just posterior to the head of the fibula. Pressure was applied to the two blades to compress the soft tissues. For each subject, measurements were made by the same physician and they were repeated until two identical results were obtained in a row. Measurements were recorded to the nearest 0.1 cm.

Linear regression analysis was carried out to derive predictive equations for the estimation of stature with adults ($\leq$50 years of age) according to the gender. This equation was then used to estimate height among elderly subjects.

2.5. Statistical analysis

During the evaluation of the data obtained from the study, Number Cruncher Statistical System (NCSS) 2007 & Power Analysis