ORIGINAL RESEARCH

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Turkish Calf Circumference Cut-offs Derived from Normative Values of Young Reference Population

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Abstract

Objective: Calf circumference (CC) is used as a simple and practical anthropometric measure for evaluating skeletal muscle mass (SMM). CC cut-offs to indicate the presence of low SMM were determined through calculation of CC values that predicted low SMM with receiver operating characteristic analyses. Also, to date CC cut-off points were obtained from older adults. Very recently, the determination of CC cut-off values derived from normative values of young reference population with normal body mass index [using one and two standard deviations (SDs) below the mean] has been suggested as an alternative CC cut-off designation method. Here, we aimed to determine the sex-specific Turkish CC cut-offs by this new CC cut-off designation method.

Materials and Methods: We included healthy young participants aged between 18 and 39, with body mass index between 18.5 kg/m^2-24.9 kg/m^2 who were free from any chronic disease or drug use. CC was measured at the widest circumference of the calf with a non-elastic tape on the non-dominant leg while the subjects were standing and CC cut-off points were calculated as one and two SDs below the mean for moderately low or severely low CC values, respectively in each sex.

Results: There were 164 participants (mean age, 25.7±4.4 years; 50% male, 50% female). Mean CC was 35.5±2.1 cm and 34.2±2.1 cm in males and females, respectively. The rounded cut-off values for moderately and severely low CC were calculated as 33 cm in males and 32 cm in females and 31 cm in males 30 cm in females, respectively.

Conclusion: This study reported CC cut-offs derived from normative values of the Turkish young reference population which can be used as a marker for the muscle mass assessment. The success of these cut-offs in prediction of SMM adequacy should be assessed in further studies.

Keywords: Calf circumference, cut-off, Turkish, normative, young reference, body mass index

Introduction

Sarcopenia is a generalized and progressive skeletal muscle disorder defined as a decline in skeletal muscle mass, strength, and function (1). It is expected that individuals with sarcopenia are increasing worldwide, given the rapid increase in older adults and individuals suffering from chronic conditions that lead to the development of sarcopenia. Sarcopenia is associated with decreased physical capacity, the development of disability, deterioration in respiratory function, reduction of cardiopulmonary performance, decrease in quality of life, decrease in basal and instrumental activities of daily living, frailty, falls and fractures, prolongation in hospitalization time, and death (2). According to the recommendation of the European Working Group on Sarcopenia in Older People (EWGSOP2), the sarcopenia diagnosis is confirmed by detecting low muscle strength and low muscle quantity or quality (1). A combination of low muscle strength, low muscle mass (LMM)/quality, and low physical performance is considered to be severe sarcopenia.

Muscle mass can be measured with dual-energy X-ray-absorptiometry (DXA), CT, and magnetic resonance imaging. All three of these imaging modalities have served as references for developing skeletal muscle mass (SMM) estimates by use of simpler, less costly means to evaluate SMM, i.e., anthropometry

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and bioelectrical impedance analysis (BIA). An anthropometric approach of interest as a marker of SMM is the calf circumference (CC) measurement. CC has been shown to predict performance and survival in older people (cut-off point <31 cm) (3). In cases where muscle mass measurement is not possible or practical through measuring devices, CC measurement can be a viable option.

CC measurement has been widely used as a muscle marker in geriatric studies and it is the most commonly used tool for muscle mass assessment in clinical practice to have an idea about the presence/absence of LMM and to screen for sarcopenia. The CC is one of the tests recommended as a case finding/screening tool for sarcopenia in the Asian Working Group for Sarcopenia (AWGS) 2019 (4). It has also been suggested as a component of the sarcopenia screening tool proposed by Ishii et al. (5) and for the SARC-CalF score (6). In addition, in EWGSOP2 consensus, CC measure has been considered to be used as a diagnostic proxy for older adults in settings where no other muscle mass diagnostic methods are available.

The calf region is comprised of a skin-fold, subcutaneous fat, and bone in addition to muscle. When a person is obese and has a high-fat mass, subcutaneous fat increases as well (7). The increase in subcutaneous fat amount will naturally translate in increase in CC in obese individuals, independent from an increase in calf muscle mass. The vice-versa is also true when the individuals are underweight. Of note, body mass index (BMI) is the most widely and globally used index to assess obesity/underweight due to its simplicity and convenience.

EWGSOP2 consensus suggested designation of LMM cut-off values as the sex specific SMM values below two standard deviations of mean values of the normative young reference population (8). On the other hand, while CC has been used as a proxy-marker of muscle mass, until recently CC cut-offs to indicate the presence of low SMM were determined through the calculation of CC values that predicted low SMM with receiver operating characteristic (ROC) analyses, by considering the SMM data derived from use of reference SMM assessment techniques. In addition, CC cut-off points in all these studies were determined from older adults (9-15).

Very recently, in 2021 Gonzalez et al. (15) suggested to derive CC cut-off values from normative values of young reference population for the first time in USA population. Moreover, considering the confounding effect of obesity/underweight in CC values, in this study, the authors suggested that the CC cut-off values should be derived from those that have normal BMI and accordingly, they derived the CC cut-offs from the young reference population that has normal BMI: 18.5-24.9 kg/m^2 (15).

Populations diverge in terms of lifestyle, environment, ethnicity and genetics, and these factors may have an effect on body composition. Accordingly, cut-off values to predict ideal BMI and obesity differ across different populations (16). Given the differences across the previously published different CC cut-off values derived in different populations (9,11,12) and considering CC as a marker of body muscle composition, this consideration should be valid for CC cut-offs as well. Hence, population-specific CC cut-off values seem to be needed.

In this study, we aimed to determine the Turkish CC cut-off values within the framework of the approach reported by Gonzalez et al. (15), by subtracting one and two SDs from the mean CC value of the young population with a BMI between 18.5-24.9 kg/m^2.

Materials and Methods

We used the data collected in our previous study at which we reported the cut-off points of LMM and low muscle strength in Turkish population (12). In this study, we identified a reference young, healthy adult reference population which was composed of 301 healthy adults aged between 18 and 39 including 187 male and 114 female individuals. We recruited these participants from the faculty students, patient relatives, and staff working in our university hospital. They were free from any chronic disease or drug use. Data from 164 healthy young adults (18-39 y) with BMI 18.5-24.9 kg/m^2 was used in this study to represent the reference population from which we calculated CC cut-off values. CC cut-offs were identified as "mean young CC minus one SD" (for moderately low SMM) and "mean young CC minus two SD" (for severely low SMM) as suggested by Gonzalez et al. (15).

Demographic data and clinical data were obtained by face-to-face interviews. Height and weight were measured via a regular stadiometer while participants were in light clothes but without shoes. We assessed the body weight to the nearest 0.1 kg and height to the nearest 0.1 cm. BMI was derived by weight (kg)/height square (m^2). CC was measured at the widest circumference of the calf with a non-elastic tape on the non-dominant leg while the subjects were standing. This study was performed according to the guidelines in the Declaration of Helsinki. We received informed consent from all volunteering participants. The study was approved by the Local Ethics Committee (number: 2021/2070).

Statistics

All data entered the database were verified by a second researcher. The variables were investigated to determine if they were normally distributed using the Shapiro-Wilk test. Continuous variables were given as mean ± standard deviation for normally distributed variables. The cut-off thresholds for CC were derived by using the mean and SD values of the young reference study population. The statistical analysis was carried

out with the statistical package SPSS Version 21.0 for Windows (SPSS Inc, Chicago, Ill, USA).

Results

There were 164 participants (82 male, 82 female). Mean age was 25.7±4.4 years, and mean CC was 35.5±2.1 and 34.2±2.1 cm in males and females, respectively. The summary, including the anthropometric measurements data are given in Table 1. The cut-offs for moderately low CC (mean young CC-one standard deviation) were calculated as 33.4 cm and 32.1 cm in males and females, respectively. The rounded cut-offs for moderately low CC were 33 and 32 in males and females, respectively. The cut-offs for severely low CC (mean young CC-two standard deviation) were calculated as 31.3 cm and 30 cm in males and females, respectively. The rounded cut-offs for severely low CC were 31 and 30 in males and females, respectively.

Table 1. The study parameters across the genders of the healthy young adults' reference population

Parameters	Males (n=82) Mean ± SD (range)	Females (n=82) Mean ± SD (range)
Age (years)	25.5±4.1	25.8±4.7
Height (cm)	174±6	162±6
Weight (kg)	69.6±6.4	56.6±5.9
BMI (kg/m^2)	22.8±1.6	21.5±1.7
Calf circumference (cm)	35.5±2.1	34.2±2.1

SD: Standard deviation, BMI: Body mass index

Discussion

We have defined the CC cut-off values using one and two SDs below the mean value of a young reference population as 33 cm and 32 cm for moderately low CC and 31 cm and 30 cm for severely low CC in males and females, respectively. In our study, the rounded CC cut-off values for moderately low CC were similar to those reported in the previously published studies which were between 33-34 cm in males (9,12-14) and 32-33 cm for females (9,11-14). Gonzalez et al. (15) determined rounded CC cut-off values for moderately and severely low CC as 34 cm and 32 cm (for males) and 33 cm and 31 cm (for females), respectively. It was also similar to the Turkish CC cut-off value of 33 cm (in both sexes) which was determined by ROC analysis using data of older adult population and reported by our group previously (12). This means that the study applies a reliable methodology for calculating the CC cut-off value and contains reliable data.

In all published studies except and up to the study by Gonzalez et al. (15), CC cut-offs were defined by a statistical method composed of ROC analysis to identify the best CC value detecting LMM measured by DXA or BIA to diagnose sarcopenia (9-14,17,18). However, in consensus reports such as EWGSOP2 and Global Leadership Initiative on Malnutrition and in many others, sex-specific low SMM cut-offs are recommended to be calculated as SMM values one or two SDs below the mean values of the normative young reference population (1,19-23). In line with these recommendations, very recently, Gonzalez et al. (15) used and suggested the use of normative reference data in the identification of low CC. As a modification, the authors suggested to determine the cut-off values from those with BMI 18.5-24.9 kg/m^2, considering the confounding effect of obesity/underweight in CC values. To ease their clinical use, they determined rounded CC cut-off values for moderately and severely low CC as 34 cm and 32 cm (for males) and 33 cm and 31 cm (for females), respectively. Based on previous studies and the data of their study, the authors stated that a moderately low CC (below the mean- one SD) might be sufficient for the screening of sarcopenia for older adults.

Studies have shown that CC values below 31 cm predicts performance and survival in older people (3). Also, in some consensus reports 31 cm has been recommended as the cut-off for CC until recently (1,24). However, it is a well-known fact that populations differ greatly in terms of genetics, lifestyle, and environment (5,9,14,25). Additionally, it is clear that a diet rich in carbohydrates and fats but poor in protein and limited physical activity affect muscle and fat content in the body. Based on previous studies, it is known that CC values also, differ among the different ethnic and race groups. Therefore, when proposing cut-offs for CC, differences at population-level were recognized, and researchers set population-specific cut-offs for CC. We have seen the accuracy of this situation from the different cut-off values derived in different populations. For example, in a study conducted in Japan, 526 adults aged 40-89 years were included and the optimal CC cut-off values by the ROC analysis were found as 34 cm in men and 33 cm in women for predicting sarcopenia (9). In another study involving 1,458 French women aged 70 and over, the suggested cut-off was 31 cm (10). In AWGS 2019 consensus report, CC cut-offs of <34 cm for men and <33 cm for women are recommended for sarcopenia screening or case-finding. In a study by Akın et al. (26) from Turkey, 879 community-dwelling older adults were recruited. The CC cut-offs were determined by the ROC analyses and they found that the area under curve for CC were significant for males aged ≥75 years (CC cut-off: 34.9 cm) and females aged ≥85 years (CC cut-off: 34.6 cm), concluding that these CC can be used as a marker of LMM especially in the older old Turkish population living in the community (26). In another study from Turkey, Halil et al. (27) conducted a multicenter study in 711 nursing home residents. They reported CC cut-off value by ROC analysis for diagnosing LMM as 35 cm. In this study, the proposed CC cut-off was not specific to age or gender group (27). In another Turkish study reported by our group, the CC

cut-off was determined as 33 cm by ROC analysis in both sexes (12). Hence all these studies indicate that CC cut-offs differ between the populations and are higher than the standard 31 cm in the Turkish population.

Sarcopenia is a reversible cause of disability, and early intervention may reverse the course of the disease. If sarcopenia is detected at an early stage and necessary interventions such as resistance exercises, optimal nutrition with adequate protein, vitamin D, and energy intake are performed, the physical disability caused by sarcopenia can be prevented. Therefore, early detection with screening and/or assessment tests is essential. Anthropometric measurement is a cheap and easily available method to estimate sarcopenia and if accuracy of CC to identify and assess LMM could be demonstrated, this will aid in earlier identification of LMM/sarcopenia and will have the potential to improve the outcomes related to LMM/sarcopenia. CC was not recommended as an assessment tool for LMM/sarcopenia so far because of the wide variation in CC due to age-related changes in fat deposits and decreased skin elasticity (1,24). While this approach is expected to improve the utility of CC as an estimate of muscle mass and sarcopenia from hypothetical point of view, future studies should be conducted to identify if use of these CC cut-offs are successful as a marker of LMM and risk factor for development of LMM/sarcopenia related adverse events.

Another thing is, a strong correlation was found between CC and appendicular low muscle index (ALMI), in several studies, including the study by Gonzalez et al. (9,15,28,29) but there is no study investigating the relationship between low CC and low appendicular or total SMM with the newly suggested CC cut-off method. Accordingly, studies on these areas are warranted. In addition, future longitudinal studies are needed to explore whether switches in the presence of LMM detected by reference SMM assessment methods can also be identified by this newly proposed CC assessment method.

Study Limitations

Our study has some limitations. The participants were not randomly selected from the Turkish population. Therefore, the sample may not have been representative of the general population. However, Istanbul is a cosmopolitan city where people from various parts of Turkey live. For this reason, we believe that the included healthy young adults may represent the Turkish population. Also, our sample size was moderate. On the other hand, to the best of our knowledge, our study is the second study that determined the cut-offs from normative values of young reference population with normal BMI. Also, it is the first study that determined population specific CC cut-offs with this method in Turkey. In this regard, we expect that our study will fill the gap in this field in our country and will provide data for comparison in studies to be conducted in other populations.

Conclusion

We reported cut-off values for CC with a new approach using one and two SD below the mean of young reference Turkish population that has normal BMI values. These CC cut-offs are intended to be used as a marker of the muscle mass evaluation with a better accuracy. Future validation studies with these cut-offs identified by this new method are needed to explore whether this new cut-off will predict outcomes related to sarcopenia and/or malnutrition (i.e., functional impairments, falls, cardio-metabolic syndrome, and mortality) better than the standard CC cut-off approach.

Ethics

Ethics Committee Approval: The study was approved by the İstanbul University Local Ethics Committee (number: 2021/2070).

Informed Consent: We received informed consent from all volunteering participants.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: T.E., C.K., Concept: T.E., G.B., Design: T.E., G.B., Data Collection or Processing: T.E., C.K., Analysis or Interpretation: T.E., G.B., Literature Search: T.E., N.M.Ç., M.A.K., G.B., Writing: T.E., N.M.Ç., M.A.K., G.B.

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