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Neck circumference is associated with nutritional status in elderly nursing home residents

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ABSTRACT

Objectives: Anthropometry is an easy and noninvasive method to evaluate nutritional status in institutionalized elderly people who are often bedridden. The aim of this study was to investigate the relationship between the neck circumference (NC) and nutritional status of elderly nursing home residents and to find cutoff points for NC size to identify individuals at risk of malnutrition.
Methods: A cross-sectional study was developed with data collected from 352 elderly people living in five public nursing homes. Different anthropometric measures and the Mini Nutritional Assessment (MNA) were used to determine nutritional status. Receiver operating characteristic (ROC) curves were built for each anthropometric variable to determine their sensitivity and specificity for predicting the risk of malnutrition according to the MNA.
Results: The mean age of the participants (59% females) was 83 years old. In total, 48.3% of women and 45.5% of men were at risk of malnutrition according to their MNA scores. All anthropometric measurements were highly intercorrelated in both men and women, indicating a high degree of collinearity. Bootstrapped linear regression was used to assess the strength of the association between an individuals' nutritional status and their anthropometric parameters. Calf circumference and NC presented the best predictive value with the highest sensitivity for diagnosing the risk of malnutrition in both institutionalized elderly men and women. The best cutoff points of NC to identify elderly nursing home residents at risk of malnutrition were 35.2 cm for females and 37.8 cm for males.
Conclusions: NC is associated with other classical anthropometric parameters and malnutrition status in elderly people living in nursing homes.

Introduction

Age is one of the factors influencing the increased prevalence of malnutrition because elderly people are a vulnerable group as a result of their biological, social, and psychological characteristics. Screening and early diagnosis of malnutrition and frailty in elderly people contributes to preventing the onset of disability and other complications [1]. At present the trend is to perform nutritional assessments through the use of non-invasive techniques to study body composition [2]. In this context, anthropometric measurements represent an important component of nutritional assessment in the elderly population [3]. In particular, the estimation of muscle mass is becoming an important tool for determining nutritional status, even outperforming laboratory parameters [4]. Because neck circumference (NC) is strongly correlated with the cross-sectional area of the neck muscles [5], reductions in NC may be an indicator of malnutrition or sarcopenia. However, the association between NC and malnutrition remains relatively unexplored [6].

In the present study we aimed to investigate the relationship between NC and other anthropometric parameters that are commonly used to assess nutritional status in elderly people living in nursing homes and to establish cutoff points of NC to identify elderly individuals at risk of malnutrition according to the Mini Nutritional Assessment (MNA) test to validate the usefulness of NC in the screening of nutritional status.

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Table 1
Characteristics of the study participants

Variables	All $n = 352$	Women $n = 207$	Men $n = 145$	P
Age (y)	83.0 (7.65)	84.3 (7.73)	81.1 (7.15)	<0.001
Weight (kg)	63.1 (14.4)	58.7 (14.0)	69.3 (12.6)	<0.001
BMI (kg/m^2)	26.5 (5.25)	26.5 (5.81)	26.5 (4.34)	0.901
Length of stay in nursing home (mo)	44.8 (13.9)	46.1 (14.7)	42.6 (13.4)	0.232
MAC	24.7 (3.66)	24.5 (4.03)	25.1 (3.03)	0.071
CC	31.0 (3.00)	30.4 (3.14)	31.8 (2.60)	<0.001
NC	35.3 (2.58)	34.1 (2.02)	36.9 (2.43)	<0.001
TST	16.3 (7.00)	19.8 (6.53)	11.4 (4.12)	<0.001
AMC	19.6 (3.16)	18.3 (2.85)	21.6 (2.50)	<0.001
MNA score	20.2 (4.40)	19.4 (4.23)	21.3 (4.40)	<0.001
MNA category				0.001
Well nourished	89 (25.3%)	39 (18.8%)	50 (34.5%)	
At risk	166 (47.2%)	100 (48.3%)	66 (45.5%)	
Malnourished	97 (27.6%)	68 (32.9%)	29 (20.0%)	

AMC, arm muscle circumference; BMI, body mass index; CC, calf circumference; MAC, midarm circumference; MNA, Mini Nutritional Assessment; NC, neck circumference; TST, triceps skinfold thickness.
Data are presented as mean (SD).
P values are for the differences between men and women.

Methods

Study design and recruitment

A multicenter cross-sectional study was performed to examine the nutritional status of 352 institutionalized geriatric individuals in five public nursing homes in Zaragoza (Spain). The inclusion criteria were residents aged older than 65 y and those who have resided in a nursing home for at least 6 mo to ensure a stable situation. The exclusion criteria were residents with acute infection, terminal disease state, active malignancy, or hospitalization during the previous 3 mo. All participants (or their legal representatives) provided signed informed consent, and the Ethics Committee for Clinical Research of Aragon (Spain) approved the study.

Anthropometric measures

Body mass index (BMI) was calculated according to body weight (kg) divided by height (m) squared. Chumlea equations to estimate height [7] and weight [8] were used in individuals not able to stand. Calf circumference (CC) was determined at the widest part of the calf. Midarm circumference (MAC) was measured at the midpoint of the relaxed, non-dominant arm between the tip of the acromion and the olecranon process. Triceps skinfold thickness (TST) was measured using skinfold calipers at the level of the midpoint between the acromion and the radius on the midline of the posterior surface of the arm. Arm muscle circumference (AMC) was calculated as MAC $-$ ($\pi \times$ TST). NC was measured immediately below the larynx (thyroid cartilage) and perpendicular to the longitudinal axis of the neck [9].

Assessment of nutritional status

MNA, specifically designed and recommended for older people [10] was administered as previously recommended [11]. Scores $\geq$24 points were considered indicative of correct nourishment, scores 17 to 23.5 were considered indicative of at risk for malnutrition, and scores <17 were considered indicative of malnutrition.

Statistical analysis

The required sample size for this study was calculated as suggested by Jones [12], and the result was that measurements of neck circumference for 352 participants were required for 90% confidence of detecting a difference of 1.4 cm or more at the 5% significance level, with an estimated standard deviation of 4 cm [6] and prevalence of malnutrition of 50% [13]. Random allocation was not necessary because we included all patients who met the inclusion criteria; hence, no selection bias was introduced. We selected patients from the five nursing homes that met the inclusion criteria until obtaining the calculated sample size. We used χ^2 tests or Student's *t* tests to compare categorical or continuous variables, respectively. The strength of the association between continuous variables was tested by Pearson's correlation coefficient. Linear regression bootstrapping was performed using the MNA score and the

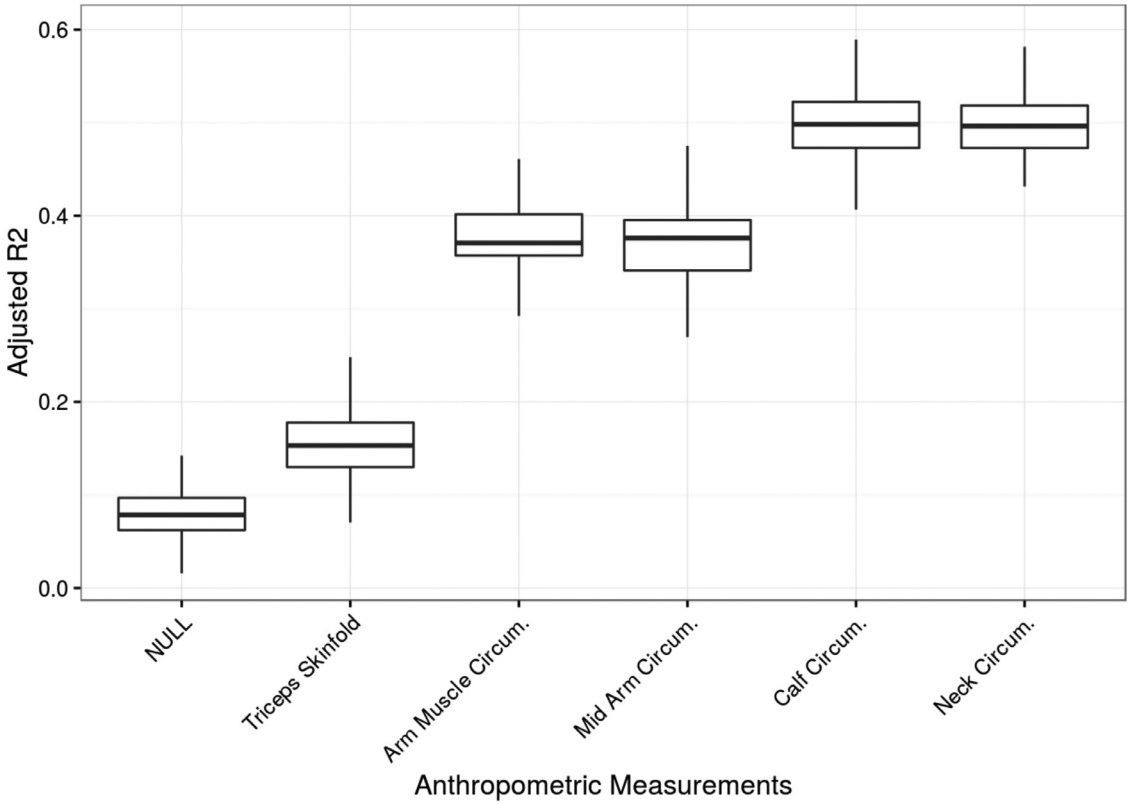

Fig. 1. Bootstrapped analysis of the regression models. Boxplots showing the distribution of the adjusted R^2 of the resampled (with replacement) linear regression models studying the association of the anthropometric measurements *(x)* and the Mini Nutritional Assessment (MNA) score *(y)*. Linear regression adjusted by sex and age was performed 100 times for each anthropometric measurement. Different letters indicate R^2 means that were significantly different in pairwise *t* tests. Circum., circumference; NULL, empty model with only age and sex to explain the MNA score.

anthropometric measures as dependent and independent variables, respectively. Each regression, containing a single anthropometric variable, was adjusted by age and sex and analyzed separately. For each equation, 352 cases were resampled (with replacement) and an ordinary least squares regression was performed. This method was repeated 100 times for each equation, and the adjusted coefficients of determination (R^2) were obtained. Sex-specific receiver operating characteristic (ROC) curves were built for each anthropometric variable to determine their sensitivity and specificity for predicting the risk of malnutrition according to the MNA score. The areas under the ROC curves (AUC) were computed with the trapezoidal rule. To determine the optimal cutoff points, the Youden index (sensitivity + specificity − 1) was considered the best compromise between sensitivity and specificity. Data were analyzed using R Version 3.1.3 (R Foundation for Statistical Computing, Vienna, Austria) and the appropriate packages. The level of significance was set at 0.05.

Results

Out of a total 582 residents at the five institutions, 42 residents were excluded because they had been institutionalized for less than 6 mo (32 were due to recent hospitalization); 47 residents were excluded because of acute infection at the time of assessment (28 were due to urinary infection with fever and 19 because of exacerbation of their chronic respiratory process); 85 residents were excluded for presenting with terminal states of advanced dementia; and 56 residents did not want to participate in the study for different reasons (mainly as a result of psychiatric problems, such as schizophrenia or depression).

Anthropometry and nutritional status

A total of 352 elderly people (59% women) participated in this multicenter cross-sectional study. The ages of the participants ranged between 65 and 100 y, and the women were older than the men. No sex differences were identified in the average BMIs or the time they lived in the nursing home. Among the analyzed anthropometric parameters, only TST was larger in women compared with men. MAC, CC, NC, and AMC were larger in men.

The average MNA score was 20.2, which was significantly higher in men than in women. Only one-quarter of the participants were well nourished, almost half of the participants were at risk of malnutrition, and one-quarter were malnourished. More women than men were found to be malnourished. These results are presented in Table 1.

Association of the MNA score with anthropometric parameters

Supplemental Figure 1 shows the pairwise Pearson correlation coefficients between the anthropometric measures and the MNA score. In women, all anthropometric measurements were highly intercorrelated, indicating a high degree of collinearity. A similar phenomenon was identified in men, although TST was less correlated with the other anthropometric parameters. The MNA score was significantly and directly correlated with MAC, NC, CC, and AMC in both men and women. The highest correlations with the MNA score were CC ($r = 0.72$ and 0.64, for women and men, respectively, both $P < 0.01$) and NC ($r = 0.69$ and 0.67 for women and men, respectively, both $P < 0.01$).

Next, we further examined the relationship between anthropometric variables and nutritional status while avoiding multicollinearity because it might occur in multivariate models. To that end, different regression models were built in which each anthropometric variable was separately evaluated as a predictor of the MNA nutritional score. The bootstrap resampling procedure was used to obtain the confidence intervals for the coefficient of determination (R^2) in each model and test the specific effects of the measured variables on the MNA score. All regression models, except the one containing TST as an independent variable, fit the data quite well, as indicated by median $R^2 > 0.35$ values across the bootstrap replicates (Fig. 1). The results from the bootstrap resampling procedure confirmed that CC and NC were able to explain a much larger fraction of the variance in MNA scores compared with MAC, NAC, and TST, the latter having the lowest explicative power.

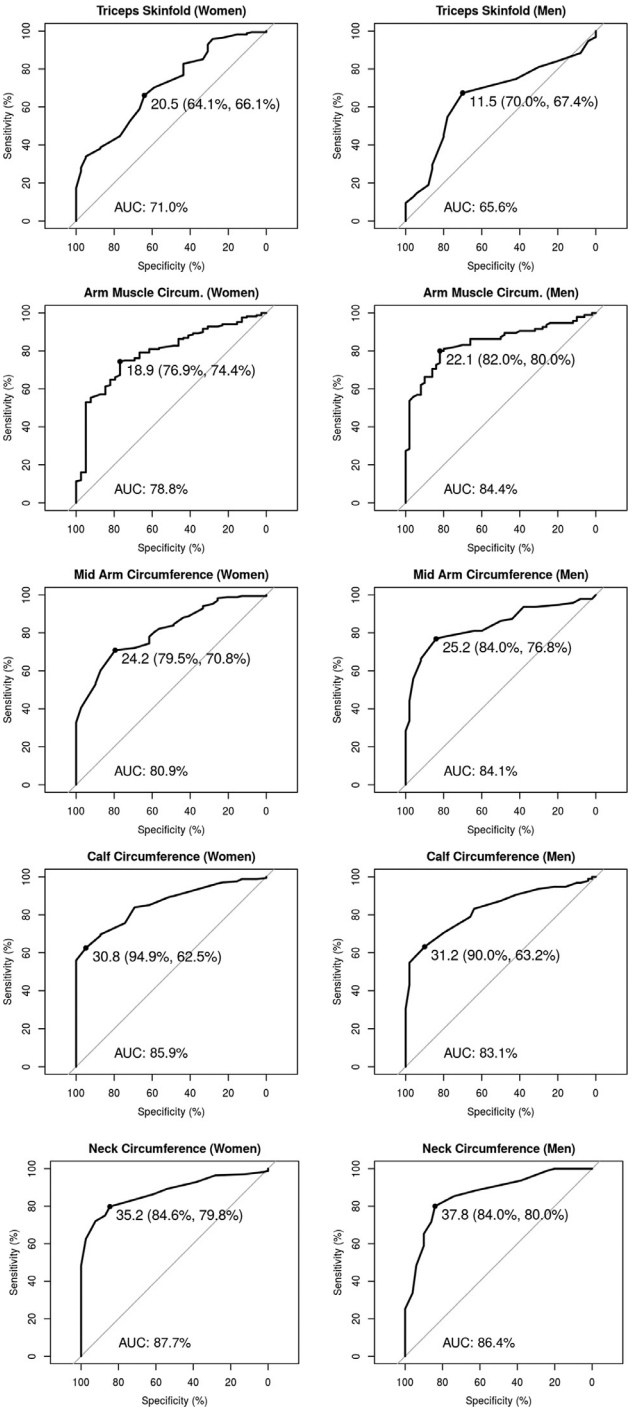

Fig. 2. Receiver operating characteristics curves indicating the area under the curve (AUC) and the optimal cutoff points, according to the Youden Index for the detection of being at risk of malnutrition, as well as its specificity and sensitivity. Circum., circumference.

Anthropometric cutoff points to identify the risk of malnutrition according to the MNA

ROC analysis was used to compare the diagnostic performance of the anthropometric measurements for detecting individuals at risk of malnutrition. Figure 2 shows that NC and CC had better predictive power (highest AUC) compared with MAC, NAC, and TST in both men and women. We then calculated the optimal cutoff points to identify individuals at risk of malnutrition. The superior AUC of NC translated into cutoff points with the highest value on the Youden Index (the maximum sum of sensitivity and specificity). For men, the 37.8 cm cutoff for NC had 80% sensitivity and 84% specificity to detect risk of malnutrition. Likewise, a NC < 35.2 cm had the best predictive value to detect elderly women at risk of being malnourished (sensitivity of 79.8% and specificity of 84.6%). These results are shown in Figure 2.

Discussion

Malnutrition is a highly prevalent condition among institutionalized elderly people. This work confirmed the following: 1) almost half of the studied nursing home residents were at risk of malnutrition, 2) anthropometric parameters commonly used in the assessment of nutritional status are highly correlated to malnutrition, and 3) out of the five studied anthropometric measurements, CC and NC presented the best predictive value with the highest sensitivity for diagnosing the risk of malnutrition in both institutionalized elderly men and women.

Anthropometry is an inexpensive and noninvasive method for assessing nutritional status [14]. The association between the MNA score and classical anthropometric parameters in the elderly has been previously described [15]. In our analysis, MAC, AMC, CC, NC, and BMI were all significantly and positively correlated among each other and with the MNA score. To assess the relative strength of these associations, we and others have used regression models. *Multicollinearity* is defined as the existence of more than one linear relationship between regressors, such as what would occur if we used multiple regression models [16]. To avoid the lack of precision of the estimators when regressors are collinear, we used separated regression models for each anthropometric measurement. In addition, by employing bootstrapping, we were able to generate confidence intervals for the coefficients of determination (R^2) of each regression model and thus compare the strength of each anthropometric parameter in predicting the MNA score. In our study, CC and NC explained the highest percentage of MNA score variance more than what MAC and AMC could explain. TST did not improve the variance explained by the null model, which was composed only of age and sex.

The rise in the prevalence of malnutrition among elderly individuals underscores the importance of using the assessment of body composition as a predictor of nutritional status and clinical outcomes [4,17]. However, devices to segment body mass, such as bioelectrical impedance analysis or duel-energy x-ray absorptionetry machines, are not usually available for daily clinical practice. In this context, direct anthropometric measurement represents a clinically relevant tool that is easily used and has an important role in the management of elderly individuals. Thus previous reports have found that MAC reflected subcutaneous adiposity, especially in women, and CC was correlated with muscle mass and fat-free mass [18–22]. However, in bedridden individuals, calf muscle becomes atrophied more rapidly than does neck muscle mass, and CC may then fail to reflect nutritional status [23]. Previous studies have also described an association between MNA score and CC [15]. In agreement with our findings, NC has been associated with obesity and its metabolic complications [24–26], and a recent study described a relationship between malnutrition and NC in elderly Japanese patients with dysphagia. Our study translates those findings into European elderly individuals living in nursing homes and, to the best of our knowledge, is the first to rank NC against other anthropometric measurements for detecting individuals at risk of malnutrition.

NC presents some advantages compared with other anthropometric measurements because it does not require undressing or any mobilization for its measurement. This may translate into increased patient privacy and time saved in anthropometric explorations.

This study has a few limitations. First, the results of our study can only be applied to a population similar to the one studied, which is elderly residents in nursing homes, and the results cannot be generalized to any elderly adults in Spain. Second, given the high percentage of possible participants who had to be excluded based on the exclusion criteria, all the elderly residents who met the inclusion criteria were included. To the best of our knowledge, this is the first study published on the relationship between malnutrition and neck circumference, so we do not have previous references for sample size calculations. We consider that this is a first approximation, and larger studies are needed to corroborate our results.

Conclusions

This work indicates that NC correlates with classical anthropometric parameters in elderly institutionalized individuals and may be a useful tool with high sensitivity for screening malnutrition in this population. In addition, we provided NC cutoff points in both men and women for identifying elderly nursing home residents at risk of malnutrition. Because malnutrition might be preventable with early screening, characterizing an individual's nutritional status may help elderly individuals avoid the dire consequences of malnutrition. However, further validation of these cutoff points in larger studies is warranted.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2019.01.015.

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