Accepted Manuscript

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

Beatriz Lardiés-Sanchez , Jose M. Arbones-Mainar , Javier Perez-Nogueras , Antonio Serrano-Oliver , Elena Torres-Anoro , Alejandro Sanz-Paris

PII: S0899-9007(18)31086-4
DOI: https://doi.org/10.1016/j.nut.2019.01.015
Reference: NUT 10444

To appear in: *Nutrition*

Received date: 23 September 2018
Revised date: 19 January 2019
Accepted date: 23 January 2019

Please cite this article as: Beatriz Lardiés-Sanchez , Jose M. Arbones-Mainar , Javier Perez-Nogueras , Antonio Serrano-Oliver , Elena Torres-Anoro , Alejandro Sanz-Paris , Neck circumference is associated with nutritional status in elderly nursing home residents, *Nutrition* (2019), doi: https://doi.org/10.1016/j.nut.2019.01.015

HIGHLIGHTS

- Neck circumference (NC) is associated with malnutrition status in the elderly
- NC correlates with anthropometric parameters in institutionalized older people
- This study provides NC cutoff-points to identify risk of malnutrition
- NC may be a useful tool for screening malnutrition in elderly population

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

Beatriz Lardiés-Sanchez [1, 2*], Jose M. Arbones-Mainar [2,3,4,*], Javier Perez-Nogueras [5], Antonio Serrano-Oliver [6], Elena Torres-Anoro [7], Alejandro Sanz-Paris[1,2]

[1]Nutrition Department of University Hospital Miguel Servet, Zaragoza, Spain

[2] Instituto de Investigación Sanitaria Aragón (IIS-Aragón), Zaragoza, Spain

[3]Adipocyte and Fat Biology Laboratory (AdipoFat), Translational Research Unit, University Hospital Miguel Servet, Instituto Aragonés de Ciencias de la Salud (IACS), Zaragoza, Spain

[4] Centro de Investigación Biomédica en Red Fisiopatología Obesidad y Nutricion (CIBERObn), Instituto Salud Carlos III, Madrid, Spain

[5] Geriatric Unit, Elias Martinez Nursing Home, Zaragoza, Spain

[6] Geriatric Unit, Casa Amparo Nursing Home, Zaragoza, Spain

[7] Geriatric Unit, Romareda Nursing Home, Zaragoza, Spain

[*] Corresponding author: Lardiés-Sánchez B. Telephone: +34 97865400. E-mail address: bealardies@gmail.com

Introduction:

Age is one of the factors influencing the increase in the prevalence of malnutrition because elderly people are a vulnerable group because of their biological, social and psychological characteristics. Screening and early diagnosis of malnutrition and frailty in elderly people contribute to preventing the onset of disability and other complications [1]. Currently, 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]. As 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 utilized 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.

Methods:

Study design and recruitment

A multicentre 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 with age≥65 years and those who have resided in a nursing home for at least six months to ensure a stable situation. The exclusion criteria were residents with acute infection, terminal disease state, active malignancy, or hospitalization during the previous three months. 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 utilized in individuals not able to stand. Calf circumference (CC) was determined at the widest part of the calf. Mid-arm 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 callipers 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- (π x TST). NC was measured immediately below the larynx (thyroid cartilage) and perpendicular to the longitudinal axis of the neck [9].

Assessment of nutritional status

The Mini Nutritional Assessment (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 17-23.5 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 subjects 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]. Randomization was not necessary as we included all patients who met the inclusion criteria; hence, no selection bias was produced. We selected patients from the 5 nursing homes that met the inclusion criteria until obtaining the calculated sample size. Chi-square tests or Student's t-tests were used 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 anthropometric measures as dependent and independent variables, respectively. Each regression, containing a single anthropometric variable, was adjusted by age and sex and analysed 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 (R2) 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 analysed using R version 3.1.3 (http://www.r-project.org) and the appropriate packages. The level of significance was set at 0.05.

Results:

Out of a total 582 residents at the 5 institutions, 42 residents were excluded because they had been institutionalized for less than 6 months (32 were due to recent hospitalization); 47 residents were excluded due to acute infection at the time of assessment (28 were due to urinary infection with fever and 19 due to 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 due to psychiatric problems, such as schizophrenia or depression).

Anthropometry and nutritional status

A total of 352 elderly people (59% women) participated in this multicentre cross-sectional study. The ages of the subjects ranged between 65 and 100 years, and the women were older than the men. No sex differences were observed in the average BMIs or the time they lived in the nursing home. Among the analysed anthropometric parameters, only TST was larger in females compared to in males. MAC, CC, NC, and AMC were larger in men.

The average MNA score was 20.2, which was significantly higher in males than in females. Only one quarter of the subjects 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.

Table 1. Characteristics of the study participants

Variables	**ALL** N=352	**WOMEN** N=207	**MEN** N=145	**p**
Age (years)	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 (months)	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%)	

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

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 observed 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, as 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 (Figure 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 to MAC, NAC, and TST, the latter having the lowest explicative power.

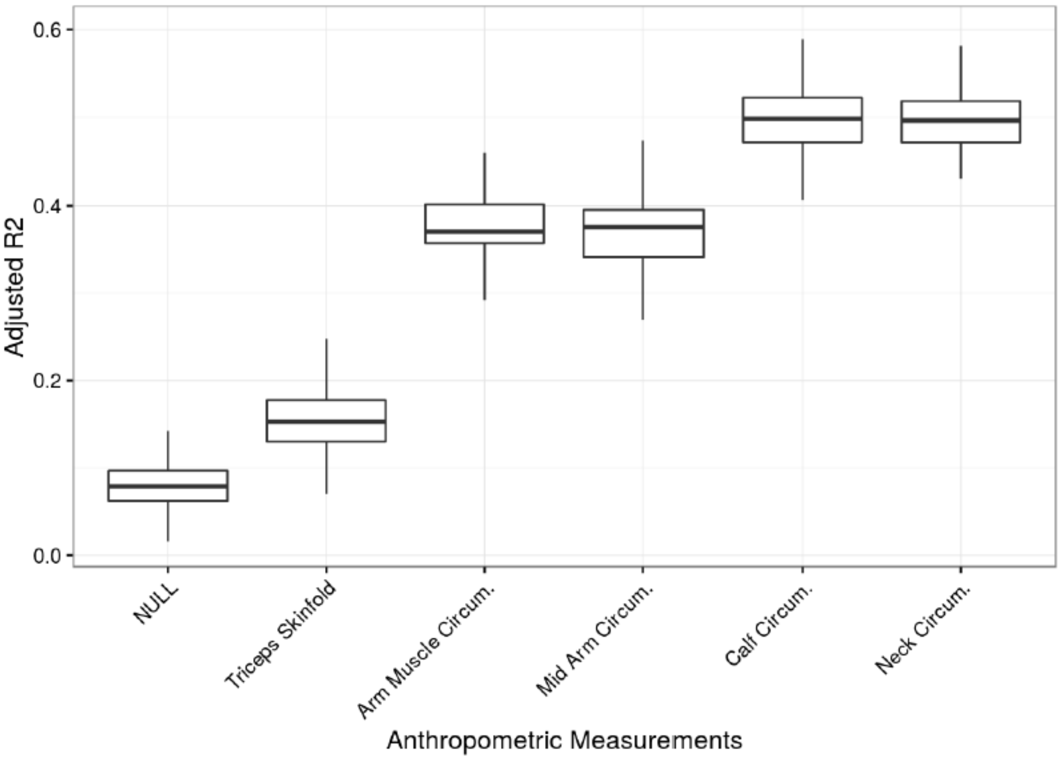

Figure 1. Bootstrapped analysis of the regression models. Boxplots showing the distribution of the adjusted R^2 of the resampled (with replacement) linear regression models studying the association of the anthropometric measurements (x) and the MNA score (y). Linear regression adjusted by sex and age was performed 100 times for each anthropometric measurement. Different letters indicate R^2 means that were significantly different in pairwise t-tests.

NULL: empty model with only age and sex to explain the MNA score.

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 to 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 males, 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.

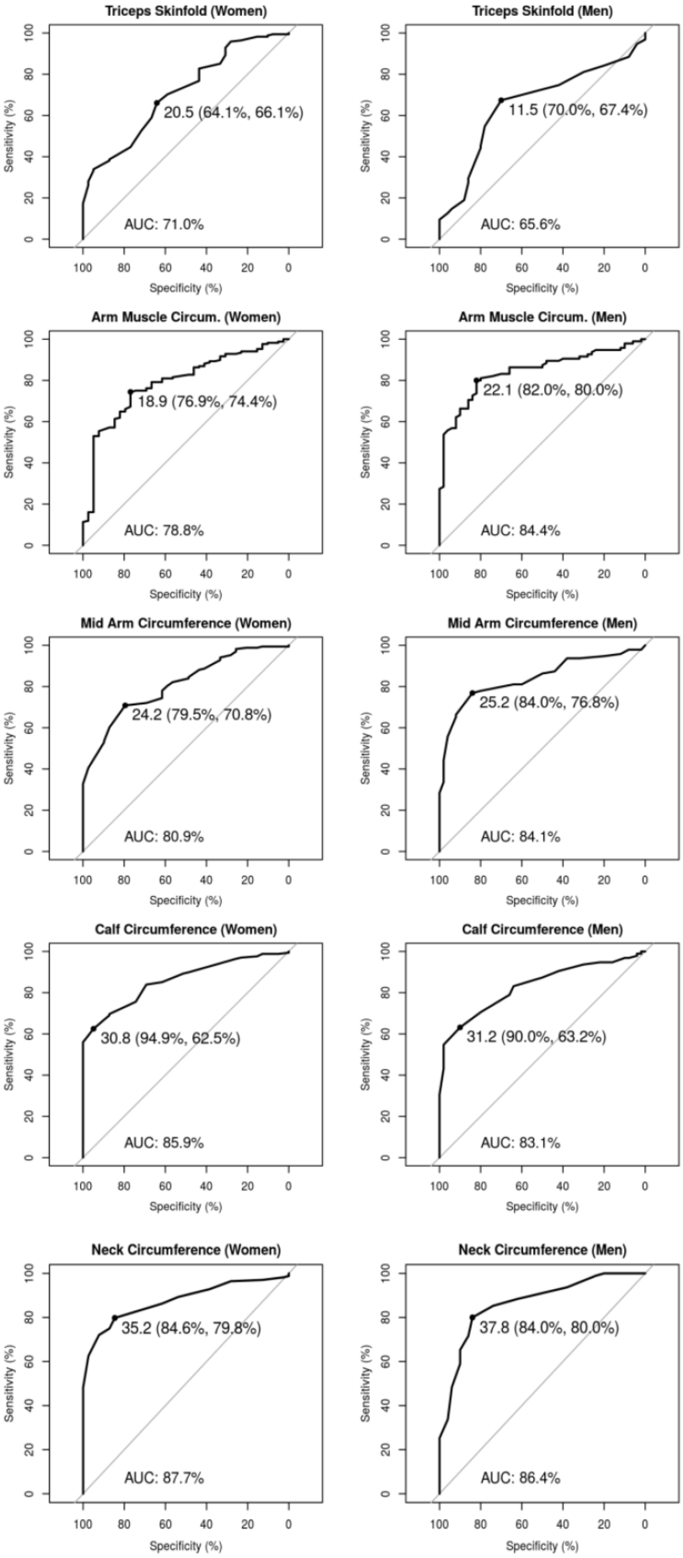

Figure 2. Receiver operating characteristics (ROC) curves indicating the area under the curve (AUC) and the optimal cutoff points, according to the Youden Index, for detecting the risk of malnutrition, as well as the specificity and sensitivity of each cutoff.

Discussion

Malnutrition is a highly prevalent condition among institutionalized elderly people. This work confirmed that i) almost half of the studied nursing home residents were at risk of malnutrition, ii) anthropometric parameters commonly used in the assessment of nutritional status are highly correlated to malnutrition, and iii) out of the 5 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. Additionally, 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, over 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 DXA machines, are not usually available for daily clinical practice. In this context, direct anthropometric measurements represent a clinically relevant tool that is easily used and has an important role in the management of elderly individuals. Thus, previous reports have shown that MAC reflected subcutaneous adiposity, especially in females, and CC was correlated with muscle mass and fat-free mass [18–22]. However, in bedridden individuals, calf muscle becomes atrophied more rapidly than neck muscle mass does, and CC may then fail to reflect their 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 to other anthropometric measurements as it does not require undressing or any mobilization for its measurement. This may translate into saved time in anthropometric explorations and increased patient privacy.

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 that had to be excluded based on the exclusion criteria, all of 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 demonstrates that NC correlates with classical anthropometric parameters in elderly institutionalized individuals and may be a useful tool for screening malnutrition in this population with high sensitivity. Additionally, we provided NC cutoff points in both men and women for identifying individuals at risk of malnutrition in elderly nursing home residents. As malnutrition might be preventable with early screening, characterizing an individual's nutritional status may help the elderly individuals avoid the dire consequences of malnutrition. However, further validation of these cutoff points in larger studies is warranted.

REFERENCES

[1] Artaza-Artabe I, Sáez-López P, Sánchez-Hernández N, Fernández-Gutierrez N, Malafarina V.The relationship between nutrition and frailty: Effects of protein intake, nutritional supplementation, vitamin D and exercise on muscle metabolism in the elderly. A systematic review. Maturitas. 2016; 93:89-99. doi: 10.1016/j.maturitas.2016.04.009.

[2] Camina-Martín MA, de Mateo-Silleras B, Malafarina V, Lopez-Mongil R, Niño-Martín V, López-Trigo JA, Redondo-del-Río MP. Nutritional status assessment in geriatrics: Consensus declaration by the Spanish Society of Geriatrics and Gerontology Nutrition Work Group. Maturitas. 2015; 81(3):414-9. doi: 10.1016/j.maturitas.2015.04.018.

[3] Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G. Anthropometric measurements in the elderly: age and gender differences. Br J Nutr 2002; 87:177. doi:10.1079/BJN2001487.

[4] Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr 2015; 34:335–40. doi:10.1016/j.clnu.2015.03.001.

[5] Dawson RM, Latif Z, Haacke EM, Cavanaugh JM. Magnetic resonance imaging-based relationships between neck muscle cross-sectional area and neck circumference for adults and children. Eur Spine J 2013; 22:446–52. doi:10.1007/s00586-012-2482-x.

[6] Wakabayashi H, Matsushima M. Neck circumference is not associated with dysphagia but with undernutrition in elderly individuals requiring long-term care. J Nutr Health Aging 2016; 20:355–60. doi:10.1007/s12603-015-0587-8.

[7] Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc 1985; 33:116–20.

[8] Chumlea WC, Guo S, Roche AF, Steinbaugh ML. Prediction of body weight for the nonambulatory elderly from anthropometry. J Am Diet Assoc 1988; 88:564–8.

[9] LaBerge RC, Vaccani JP, Gow RM, Gaboury I, Hoey L, Katz SL. Inter-and intra-rater reliability of neck circumference measurements in children. Pediatr Pulmonol 2009; 44:64–9.

[10] Turnbull PJ, Sinclair AJ. Evaluation of nutritional status and its relationship with functional status in older citizens with diabetes mellitus using the mini nutritional assessment (MNA) tool--a preliminary investigation. J Nutr Heal Aging 2002; 6:185–9.

[11] Guigoz Y, Vellas B, Garry PJ, Vellas BJ, Albarede JL. Mini Nutritional Assessment: a practical assessment tool for grading the nutritional state of elderly patients. Mini Nutr Assess MNA Nutr Elderly. 1997;15–60.

[12] Jones JM. Validity of Nutritional Screening and Assessment Tools. Nutrition. 2004; 20(3):312-7.

[13] Mila Villarroel R, Formiga F, Duran Alert P, Abellana Sangra R. Prevalence of malnutrition in the Spanish elderly population: a systematic review Med Clin 2012; 139(11): 502–8.

[14] World Health Organization. Physical status: The use of and interpretation of anthropometry, Report of a WHO Expert Committee. Geneva: World Health Organization; 1995.

[15] Leandro-Merhi VA, De Aquino JLB, De Camargo JGT. Agreement between body mass index, calf circumference, arm circumference, habitual energy intake and the MNA in hospitalized elderly. J Nutr Health Aging 2012; 16:128–32.

[16] Belsley DA, Kuh E, Welsch RE. Regression diagnostics: Identifying influential data and sources of collinearity. vol. 571. John Wiley & Sons; 2005.

[17] Sanz-París A, Gómez-Candela C, Martín-Palmero Á, García-Almeida JM, Burgos-Pelaez R, Matía-Martin P, et al. Application of the new ESPEN definition of malnutrition in geriatric diabetic patients during hospitalization: a multicentric study. Clin Nutr 2016; 35:1564–7. doi:10.1016/j.clnu.2016.02.018.

[18] Rolland Y, Lauwers- Cances V, Cournot M, Nourhashémi F, Reynish W, Rivière D, et al. Sarcopenia, Calf Circumference, and Physical Function of Elderly Women: A Cross- Sectional Study. J Am Geriatr Soc 2003; 51:1120–4.

[19] Papandreou D, Noor ZT, Rashed M, Al Jaberi H. Association of Neck Circumference with Obesity in Female College Students. Open Access Maced J Med Sci 2015; 3:578.

[20] Bonnefoy M, Jauffret M, Kostka T, Jusot JF. Usefulness of calf circumference measurement in assessing the nutritional state of hospitalized elderly people. Gerontology 2002; 48:162–9.

[21] Campbell TM, Vallis LA. Predicting fat-free mass index and sarcopenia in assisted-living older adults. Age (Omaha) 2014; 36:1–13.

[22] Kawakami R, Murakami H, Sanada K, Tanaka N, Sawada SS, Tabata I, et al. Calf circumference as a surrogate marker of muscle mass for diagnosing sarcopenia in Japanese men and women. Geriatr Gerontol Int 2015; 15:969–76.

[23] Nuhlicek DN, Spurr GB, Barboriak JJ, Rooney CB, El Ghatit AZ, Bongard RD. Body composition of patients with spinal cord injury. Eur J Clin Nutr 1988;42: 765–73.

[24] Ben- Noun LL, Laor A. Relationship of neck circumference to cardiovascular risk factors. Obes Res 2003; 11:226–31.

[25] Yang G, Yuan S, Fu H, Wan G, Zhu L, Bu X, et al. Neck circumference positively related with central obesity, overweight, and metabolic syndrome in Chinese subjects with type 2 diabetes: Beijing Community Diabetes Study 4. Diabetes Care 2010; 33:2465–7.

[26] Stabe C, Vasques ACJ, Lima MMO, Tambascia MA, Pareja JC, Yamanaka A, et al. Neck circumference as a simple tool for identifying the metabolic syndrome and insulin resistance: results from the Brazilian Metabolic Syndrome Study. Clin Endocrinol (Oxf) 2013; 78:874–81