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MID-UPPER ARM CIRCUMFERENCE (MUAC) FOR DETECTING MALNUTRITION IN HOSPITALIZED ELDERLY

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Abstract: *Objective:* This study investigated the relationship between mid-upper arm circumference and other nutritional assessment indicators to be used as a tool for the nutritional diagnosis of the elderly. *Methods:* Anthropometry was used for the nutritional assessment of 123 hospitalized elderly patients with subsequent investigation of the relationship between mid-upper arm circumference (MUAC) and the other indicators. The Mann-Whitney test was used for comparing the data and the Spearman's linear correlation coefficient was used for assessing the association between the variables. The receiver operator characteristic (ROC) curve was constructed for determining the cut-off. *Results:* A positive and significant correlation was found between MUAC and other indicators in the whole group and by gender, except between MUAC and waist-to-hip ratio. MUAC differed significantly from the other indicators, suggesting that MUAC can also be used as an indicator of malnutrition in this casuistic. For the construction of the ROC curve, the gold standard was risk estimated by body mass index since correlated best with MUAC. The ROC curve identified a cut-off point of 28.25 cm, with high sensitivity (87.10%) and high specificity (76.09%). *Conclusion:* The use of MUAC has practical implications for the nutritional assessment of hospitalized elderly, especially if a greater cut-off point is used for the population.

Key words: Nutritional status, arm circumference, anthropometry, hospitalized elderly, ROC curve.

Introduction

Given that ageing is frequently accompanied by a loss of nutritional status and functional capacity, contributing for the development of malnutrition, the nutritional status of the elderly has been investigated by different assessment instruments in an attempt to diagnose malnutrition and, consequently, establish strategies for controlling and monitoring this situation (1-4). Malnutrition has been pointed out as an important clinical situation among hospitalized elderly. Its prevalences have been reported by many studies around the world, for example, 44% in patients from a study done by Saka et al, 2010 (3); 46.5% by Amaral et al, 2010 (4); 66.2% by Oliveira et al, 2009 (2) when malnourished individuals are combined with those at risk of malnutrition, and 33% by Vanderwee et al, 2010 (5) in a Belgium study that investigated malnutrition and related factors.

Anthropometry is a critical tool for the diagnosis of hospitalized elderly. Anthropometry has been shown to be a good indicator for making a general assessment of the elderly, with the advantage of being inexpensive, easy to use and non-invasive (6, 7).

The most commonly used anthropometric measurements such as body weight, height, body mass index, circumferences and skinfold thicknesses are important indicators of the nutritional status of the elderly. But although body mass index is a good indicator, its specificity for assessing malnutrition in clinical cases where changes in body composition occur because of the disease is not well known (8-10). Another limitation regards the fact that a patient may be considered normal weight according to BMI while malnourished or overweight according to another indicator.

Finally, considering that many hospitalized elderly are bedridden, which makes it impossible to weigh them, the objective of this study was to investigate the relationship between mid-upper arm circumference (MUAC) and other assessment indicators used for the nutritional diagnosis of the elderly.

Casuistic and method

This was a cross-sectional study done at the Hospital e Maternidade Celso Pierro, of the Pontifical Catholic

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University of Campinas-SP-Brazil, between 2011 and 2012, after approval by the hospital's Research Ethics Committee under protocol number (Protocolo nº 743/09). A total of 123 hospitalized elderly patients from the surgery ward were selected. They had been hospitalized for clinical and/or surgical treatment. Recently hospitalized patients who had been nutritionally assessed in the first 48 hours of hospitalization with the following inclusion criteria were selected: nutritional diagnosis done at the beginning of the hospitalization period and no terminal illnesses. Patients with edema or ascites were excluded, or those undergoing hemodialysis or with psychiatric illness.

The data were collected at the beginning of the hospitalization period using a previously developed protocol with personal identification data and nutritional indicators (anthropometry) for nutritional status assessment, such as: weight, height, body mass index (BMI), wrist circumference, calf circumference, mid-upper arm circumference (MUAC), triceps skinfold thickness (TST), subscapular skinfold thickness (SSST), mid-upper arm muscle circumference (MUAMC), mid-upper arm muscle area (MUAMA), mid-upper arm fat area (MUAFA), waist circumference (WC), and waist-to-hip ratio (WHR). BMI was calculated and classified according to the criteria established by Lipschitz (1994), for individuals aged $\geq$ 60 years (11) with the following cut-off points: BMI$\leq$22 as underweight (malnourished), >22<27 as normal weight and $\geq$27 as having excess weight. For the indicators of body composition, MUAC, MUAMC, MUAMA, TST and MUAFA were classified according to the reference values of percentile distribution established by Frisancho (1990) (12) for individuals aged less than 65 years. For those aged $\geq$ 65 years the reference values established by Burr & Phillips (1984) (13) were used. Calf circumference was classified according to the World Health Organization (WHO) (14) standard for the elderly, with a cut-off point of $\geq$31 cm.

Later, the relationship between MUAC and the other nutritional status indicators was compared. In this study, risk of malnutrition was determined by the cut-off points defined in the literature as follows: risk according to BMI (BMI<22kg/m^2); risk according to calf circumference (calf circumference <31 cm). MUAC was then compared with these two indicators.

Statistical analysis

Firstly, a descriptive analysis was done for characterization of the study patients. Next, the Mann-Whitney test was used for comparing the numerical measurements between the two groups (Female and Male, Table 2; and No and Yes, Table 4). Then, Spearman's linear correlation coefficient was used for verifying the linear association between the two variables (MUAC and the other numerical indicators). This coefficient varied from -1 to 1. Values close to the extremes indicated negative or positive correlation, respectively, and values close to zero indicated no correlation. Later, the receiver operator characteristic (ROC) curve was used for determining the cut-off values and expressing the relationship between the sensitivity and specificity of a given test. The significance level was set at 5% for all statistical tests (15-17).

Results

The 123 hospitalized elderly patients consisted of 61 females (49.6%) and 62 males (50.4%). The BMI, CC and MUAC of the sample were classified according to the cut-off points given by the literature (Table 1). The genders differed significantly with respect to length of hospital stay, weight, height, wrist circumference, triceps skinfold thickness, subscapular skinfold thickness, waist-to-hip ratio, MUAMC, MUAMA and MUAFA (Table 2). Table 3 shows correlations of the entire group and by gender. There was a positive and significant correlation between MUAC and the other indicators of the entire group and by gender, except for the waist-to-hip ratio (Table 3). Hence, the other analyses associating the indicators of risk of malnutrition were done only for the entire group, since there was no significant difference between the genders.

Table 1
General description of the study variables

Variables		N	%
Gender	Female	61	49.6
	Male	62	50.4
Body mass index	Excess weight	36	29.3
	Normal weight	56	45.5
	Underweight	31	25.2
Risk of malnutrition according to BMI (<22)	No	92	74.8
	Yes	31	25.2
Risk of malnutrition according to CC (<31 cm)	No	103	83.7
	Yes	20	16.3
Risk of malnutrition according to MUAC (≤ 22 cm)	No	118	96.0
	Yes	5	4.0

BMI: body mass index; CC: calf circumference; MUAC: mid-upper arm circumference.

Table 4 shows a descriptive analysis and a comparison between MUAC and the other indicators for the assessment of malnutrition (risk according to BMI and CC). There was a significant difference between MUAC and all other indicators, suggesting that this measurement may also be used as an indicator of

malnutrition in this casuistic.

Table 2
Comparison of the study variables between genders (N= 123 patients)

Study variables	N	X ± SD	Median	P-value *
Age (years)				
Female	61	70.0±7.2	69.0	0.8691
Male	62	70.3±7.8	69.0	
Length of hospital stay (days)				
Female	61	4.0±4.1	3.0	0.0175
Male	62	4.9±5.3	3.0	
Current weight (kg)				
Female	61	66.0±13.5	63.0	0.0228
Male	62	71.1±12.9	70.0	
Height (m)				
Female	61	1.6±0.06	1.6	<0.0001
Male	62	1.7±0.07	1.7	
Body mass index (kg/m2)				
Female	61	26.3±5.2	24.5	0.1466
Male	62	24.3±4.1	24.5	
Calf circumference (cm)				
Female	61	34.6±4.3	34.0	0.3266
Male	62	33.9±3.5	34.0	
Wrist circumference (cm)				
Female	61	15.6±1.9	16.0	<0.0001
Male	62	17.2±1.5	17.0	
Mid-upper arm circumference (cm)				
Female	61	30.2±4.8	30.0	0.1544
Male	62	29.0±3.9	29.0	
Triceps skinfold thickness (cm)				
Female	61	25.4±9.5	24.0	<0.0001
Male	62	15.8±7.2	15.5	
Mid-upper arm muscle circumference (cm)				
Female	61	222.9±34.1	218.4	0.0027
Male	62	240.6±32.9	240.4	
Subscapular skinfold thickness				
Female	61	21.8±8.4	20.0	0.0019
Male	62	17.3±7.0	17.8	
Mid-upper arm muscle area				
Female	61	4047.2±1289.7	3796.2	0.0027
Male	62	4694.8±1308.3	4601.3	
Mid-upper arm fat area				
Female	61	3414.2±1578.0	3013.8	<0.0001
Male	62	2127.0±1046.2	2177.6	
Waist circumference				
Female	61	90.8±13.5	90.0	0.5864
Male	62	91.9±11.8		
Waist-to-hip ratio				
Female	60	0.90±0.08	0.91	0.0034
Male	61	0.95±0.09	0.95	

* Mann-Whitney test.

Since MUAC was correlated with the other study indicators, the possibility of obtaining a cut-off point for MUAC that discriminates those at risk of malnutrition was also investigated. For this purpose a ROC curve was constructed (Figure 1), using as gold standard the risk according to BMI, since it presented the greatest correlation coefficient with MUAC, as shown in Table 4. The ROC curve identified a cut-off point of 28.25 cm, with high sensitivity (87.10%) and high specificity (76.09%) (Figure 1).

Figure 1
ROC curve for mid-upper arm circumference for discriminating malnutrition according to body mass index (<22). Accuracy of the cut-off value: MUAC ≤ 28.25; sensitivity 87.10%; specificity 76.09%

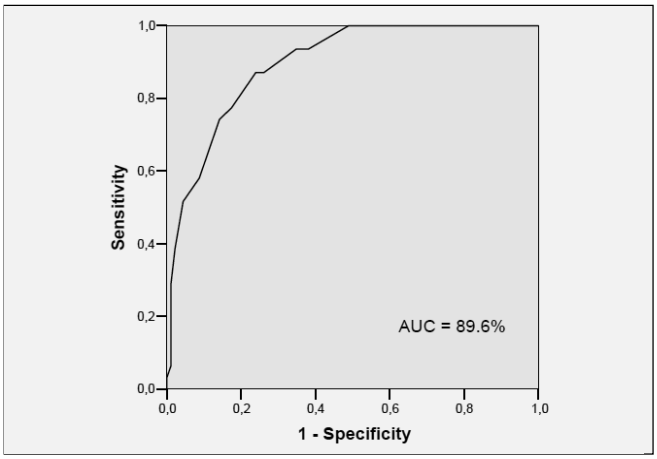

Table 3
Spearman's correlation coefficient between mid-upper arm circumference and the other indicators

Correlation		Total population (N=123)	Females (N=61)	Males (N=62)
MUAC vs BMI	r	0.81375	0.84818	0.77347
	p-value	<.0001	<.0001	<.0001
MUAC vs WrC	r	0.34106	0.52473	0.41904
	p-value	0.0001	<.0001	0.0007
MUAC vs CC	r	0.58547	0.55523	0.60081
	p-value	<.0001	<.0001	<.0001
MUAC vs TST	r	0.56954	0.66743	0.57998
	p-value	<.0001	<.0001	<.0001
MUAC vs SEST	r	0.73815	0.78077	0.72057
	p-value	<.0001	<.0001	<.0001
MUAC vs MUAMC	r	0.72274	0.83272	0.77736
	p-value	<.0001	<.0001	<.0001
MUAC vs MUAMA	r	0.72274	0.83272	0.77736
	p-value	<.0001	<.0001	<.0001
MUAC vs MUAFA	r	0.73165	0.81063	0.72928
	p-value	<.0001	<.0001	<.0001
MUAC vs WC	r	0.68569	0.76878	0.62607
	p-value	<.0001	<.0001	<.0001
MUAC vs WHR	r	0.26054	0.39925	0.18043
	p-value	0.0039	0.0016	0.1641

BMI: body mass index; WrC: wrist circumference; CC: calf circumference; TST: triceps skinfold thickness; SEST: subscapular skinfold thickness; MUAMC: mid-upper arm muscle circumference; MUAMA: mid-upper arm muscle area; MUAFA: mid-upper arm fat area; WC: waist circumference; WHR: waist-to-hip ratio.

Table 4
Descriptive analysis and comparison of arm circumference between the risk indicators for malnutrition assessment

Study variables	N	Mid-upper arm circumference X ± SD	Median	P-value *
Risk according to BMI (BMI < 22kg/m²)				
No	92	31.0±3.9	30.5	<0.0001
Yes	31	25.3±2.8	25.0	
Risk according to CC (CC <31 cm)				
No	103	30.3±3.9	30.0	0.0001
Yes	20	26.1±5.0	25.5	

* Mann-Whitney test; BMI: body mass index; CC: calf circumference.

Discussion

The present study assessed the nutritional status of elderly patients staying in a university hospital and found that 25.2% of the sample was at risk of malnutrition according to their BMI; 16.3% was at risk of malnutrition according to their calf circumference and 4% was at risk of malnutrition according to their MUAC. Malnutrition and its prevalence is very hard to estimate since it may vary greatly depending on the instrument used and the type of population assessed. In this study, many anthropometric indicators of the institution's routine were necessary. This study chose to explore a little more the use of MUAC for two reasons: first, because it could be used for bedridden patients who cannot be weighed and, second, because calf circumference had already been studied in another study (18) (which showed a positive correlation between calf circumference and the nutritional status of the elderly, indicating its use as a complementary tool for this purpose.

Among the study elderly, men had longer hospital stays than women (4.9 versus 4.0 days, p=0.0175). Other studies have shown lengths of hospital stay of 10.3 days 19), 21.7 days 5 and 5.3 days (20) for the elderly.

A recent study by Tsai et al, 2012 (10) compared the ability of BMI, MUAC and CC to predict nutritional status, functional capacity and death risk among the elderly. The authors showed that CC was the best index for predicting nutritional status, functional capacity and general health status; MUAC was best for predicting death risk and BMI was the worst for predicting all items (10). In another study, the prevalence of malnutrition according to BMI was the same as that given by MUAC and TST (9) in a group of elderly and cancer patients, evidencing that BMI was more strongly correlated with MUAMC and TST in a group of elderly and cancer patients, and more weakly correlated in a group of patients with cirrhosis. It is important to point out that fluid retention is the main factor limiting the use of BMI as it may indicate a false increase of body weight (9). Meanwhile, the functional status of the elderly seems to be associated with higher BMI (above 30 kg/m²) (8).

Nutritional depletion in hospitalized elderly is very common and the use of various indicators and instruments for the investigation of this nutritional status has been widely explored by the mini nutritional assessment (5, 8, 21) and by anthropometry (4, 7, 8, 10, 21-23) in many studies that investigated this population. Meanwhile, the indicators investigated in the present study are not the same ones investigated by other studies, which reinforces the importance of this study. It is pertinent to use different diagnostic criteria for malnutrition in the elderly because it allows a more sensitive detection of malnutrition and, consequently, treatment efficacy, since the elderly are a vulnerable group. In this line of investigation, López-Contreras et al 2012 (24) studied 10 diagnostic criteria for malnutrition in the elderly and the proportion of malnutrition varied from 2% to 57%. The study by Tsai et al, 2012, (10) also assessed many anthropometric indicators, as cited earlier, indicating the relevance of the use of MUAC and CC. MUAC may also be a more useful nutritional indicator than BMI in individuals with unilateral amputation (25).

The risk of malnutrition according to the MUAC cut-off point given by the literature (13) (Table 1) was low for the present sample when compared with the risk given by BMI and CC. However, when a comparison was done between MUAC and BMI and CC (Table 4), mean MUAC values of 25.3±2.8 cm for those at risk according to BMI and 26.1±5.0 cm for those at risk according to CC were found, both with a significant difference (p<0.0001 and p=0.0001).

Thus, our data show that MUAC is a good indicator of risk of malnutrition in this population. For all indicators, there was a significant difference in relation to MUAC, which always returned lower numbers for risk of malnutrition when compared with other indicators. Based on this, the ROC curve was constructed to establish a cut-off point for MUAC, which resulted in a value of ≤ 28.25 for discriminating the risk of malnutrition in the elderly, with high sensitivity and high specificity. That is, with a cut-off point of 28.25 cm, the number of malnourished elderly would be greater. A cut-off point of ≤ 26.2 for MUAC has already been determined by the ROC curve in a work that assessed the agreement between anthropometry and the mini nutritional assessment in hospitalized elderly (26) and another (27) pointed MUAC as a predictive factor of the MNA. Yet another study(28) found that low MUAC had high specificity and low sensitivity when compared with malnutrition indicators and percentiles based on a healthy population. Others pointed out that MUAC and CC are significantly correlated with general health indicators, such as the number of chronic diseases, length of hospital stay, and number of emergency visits (10).

Conclusion

The results show that the use of MUAC must have practical implications in the nutritional assessment of hospitalized elderly, especially if a greater cut-off point is used for the population.

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References

1. Galesi LF, Leandro-Merhi VA, Oliveira MRM. Association between indicators of dementia and nutritional status in institutionalised older people. International Journal of Older People Nursing 2012. doi: 10.1111/j.1748-3743.2012.00321.x
2. Oliveira MRM, Fogaça KCP, Leandro-Mehri VA. Nutritional status and functional capacity of hospitalized elderly. Nutrition Journal 2009; 8:54. doi: 10.1186/1475-2891-8-54.
3. Saka B, Kaya O, Ozturk GB, Erten N, Karan MA. Malnutrition in the elderly and its relationship with other geriatric syndromes. Clinical Nutrition 2010; 29(6):745-748. doi: 10.1016/j.clnu.2010.04.006.
4. Amaral TF, Matos LC, Teixeira MA. Tavares MM, Álvares L, Antunes A. Undernutrition and associated factors among hospitalized patients. Clinical Nutrition 2010; 29(5):580-585. doi: 10.1016/j.clnu.2010.02.004.
5. Vanderwee K, Clays E, Bocquaert I, Gobert M, Folens B, Defloor T. Malnutrition and associated factors in elderly hospital patients: a Belgian cross-sectional, multi-centre study. Clinical Nutrition 2010; 29(1):469-476.
6. Félix LN, Souza, EMT. Avaliação nutricional de idosos em uma instituição por diferentes instrumentos. Revista de Nutrição 2009; 22(4):571-580.
7. Ngoh HJ, Chen ST, Harith S. Anthropometric measurements among institutionalized elderly men in Northern Peninsular Malaysia. Journal of Men's Health 2011; 8(1):s58-62.
8. Bahat G, Tufan F, Saka B , Akin S, Ozkaya H, Yucel N, Erten N, Karan MA. Which body mass index (BMI) is better in the elderly for functional status? Archives of Gerontology and Geriatrics 2012; 54(1):78-81. doi: 10.1016/j.archger.2011.04.019.
9. Campillo B, Paillaud E, Uzan I, Merlier I, Abdellaoui M, Perennec J, Louarm F, Bories PN. Value of body mass index in the detection of severe malnutrition: influence of the pathology and changes in anthropometric parameters. Clinical Nutrition 2004; 23(4):551-559.
10. Tsai ACH, Lai MC, Chang TL. Mid-arm and calf circumferences (MAC and CC) are better than body mass index (BMI) in predicting health status and mortality risk in institutionalized elderly Taiwanese. Archives of Gerontology and Geriatrics 2012; 54(3):443–447.
11. Lipschitz DA. Screening for nutritional status in the elderly. Prim Care 1994; 22(1): 55-67.
12. Frisancho AR. Anthropometric standards for the assessment of growth and nutritional status. Michigan: The University of Michigan Press; 1990.
13. Burr ML, Phillips MK. Anthropometric norms in the elderly. British Journal of Nutrition 1984; 51:165-9.
14. World Health Organization. Physical status: the use and interpretation of anthropometry: report of a WHO Expert Committee. Geneva: WHO; 1995.
15. Conover, W.J. (1999). Practical Nonparametric Statistics. 3ª ed. John Wiley & Sons Inc. Nova Iorque.
16. Fletcher R.; Fletcher, S.(2005). Clinical Epidemiology: The Essentials. 4ª ed. Lippincott Williams & Wilkins. Philadelphia, Pennsylvania. USA.
17. SAS System for Windows (Statistical Analysis System), versão 9.2. SAS Institute Inc, 2002-2008, Cary, NC, USA.
18. Mclellan KCP, Staudt C, Silva FRF, Bernardi JLD, Frenhani PB, Leandro-Merhi VA. The use of calf circumference measurement as an anthropometric tool to monitor nutritional status in elderly inpatients. The Journal of Nutrition, Health & Aging 2010; 14(4):266-270.
19. Gamaletsou MN, Poulia KA, Karageorgou D, Yannakoulia M, Ziakas PD, Zampelas A, Sipsas NV. Nutritional risk as predictor for healthcare-associated infection among hospitalized elderly patients in the acute care setting. Journal of Hospital Infection 2012; 80:168-172. doi: 10.1016/j.jhin.2011.08.020.
20. Leandro-Mehri VA, Portero-McLellan KC, Bernardi JLD, Frenhani PB, Camargo JGT, Aquino JLB. Dental and gastrointestinal changes as indicators of nutritional depletion in elderly inpatients. Journal of Evaluation in Clinical Practice 2010; 16:873-877. doi: 10.111/j.1365-2753.2009.01200.x
21. Banks LN, Byrne N, Henari S, Morris S, McElwain JP. Nutritional status of elderly trauma patients presenting to a South Dublin Teaching Hospital. European Geriatric Medicine 2010; 1:325-329. doi: 10.1016/j.eurger.2010.09.002
22. Santos JL, Albala C, Lera L, García C, Arroyo P, Pérez-Bravo F, Angel B, Peláez M. Anthropometric measurements in the elderly population of Santiago, Chile. Nutrition 2004; 20(5):452-457. doi: 10,1016/j.nut.2004.01.010
23. Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G. Anthropometric measurements in the elderly: age and gender differences. British Journal of Nutrition 2002; 87:177-186. doi: 10.1079/BJN2001487
24. López-Contreras MJ, Torralba C, Zamora S, Pérez-Llamas F. Nutrition and prevalence of undernutrition assessed by different diagnostic criteria in nursing homes for elderly people. Journal of Human Nutrition and Dietetics 2012; 1-8. doi: 10.1111/j.1365-277X.2012.01237.x
25. Miller M, Wong WK, Wu J, Cavenett S, Daniels L, Crotty M. Upper-arm anthropometry: an alternative indicator of nutritional health to body mass index in unilateral lower-extremity amputees? Archives of Physical Medicine and Rehabilitation 2008; 89(10):2031-2033.
26. Leandro-Merhi VA, Aquino JLB, Camargo JGT. Agreement between body mass index, calf circumference, arm circumference, habitual energy intake and the MNA in hospitalized elderly. The Journal of Nutrition, Health & Aging 2012; 16(2):128-132.
27. Leandro-Merhi VA, Aquino JLB. Anthropometric parameters of nutritional assessment as predictive factors of the mini nutritional assessment (MNA) of hospitalized elderly patients. The Journal of Nutrition, Health & Aging 2011; 15(3):181-186.
28. Burden ST, Stoppard E, Shaffer J, Makin A, Todd C. Can we use mid upper arm anthropometry to detect malnutrition in medical inpatients? A validation study. Journal of Human Nutrition and Dietetics 2005; 18(4):287–294.