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Adductor pollicis muscle and handgrip strength: potential methods of nutritional assessment in surgical patients

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Abstract

Measurements of the adductor pollicis muscle thickness (APMT) and handgrip strength (HGS) are easy and quick to apply, low cost, and may detect changes in nutritional status in the short term. The use of these measurements would speed up the nutritional diagnosis and optimize the care of hospitalized patients. The aim of this study was to evaluate the association between APMT and HGS with anthropometric parameters, subjective global assessment (SGA), and biochemical markers in patients admitted for digestive tract and adnexal organ surgery. This is a cross-sectional study in which body mass index (BMI), arm circumference (AC), triceps skinfold thickness, arm muscle circumference, APMT, HGS, SGA and biochemical variables were evaluated. A total of 56 patients participated, showing that the increase of one unit in the AC promoted an increase of 0.73 kgf in the HGS (95%CI: 0.30;1.17, p=0.002). A one-unit increase in normal weight, AC, and serum albumin adjusted for height, age, and gender was associated with higher APMT values (normal weight: 0.92 mm, 95%CI: 0.18;1.66, p=0.017; AC: 0.69 mm, 95%CI: 0.27;1.11, p=0.006; serum albumin 1.83 mm, 95%CI: 0.10;3.57, p=0.039). On the other hand, the increase of one unit in weight loss (%) and BMI resulted in a reduction of 0.85 mm (95%CI: -1.46;-0.25, p=0.008) and 2.80 mm in the APMT (95%CI: -4.73;-0.88, p=0.006), respectively. There is a positive association between HGS and AC and between APMT, normal weight, AC, and serum albumin, and an inverse association between APMT, BMI, and percentage of weight loss.

Keywords: Anthropometry. Nutritional status. Hospitalization. Patient care.

INTRODUCTION

Digestive tract surgery is a medical specialty that treats, through surgical procedures, benign and malignant diseases that affect the gastrointestinal tract, including adnexal glands such as the liver, pancreas, and biliary tract. Hospital malnutrition is common, both in developed and developing countries, reaching a prevalence between 30 and 50% of hospitalized patients[1].

The surgical procedure promotes an imbalance in the patient's physical, mechanical, chemical, and emotional

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homeostasis, depending on the intensity of the injury, which can trigger hypermetabolism, hypercatabolism, reduced dietary intake, and insufficient absorption of nutrients that culminate in the degradation of protein mass[2]. Hospital malnutrition is a potential source of increased morbidity and mortality in surgical patients, in addition to increasing the length of stay, readmission rate, and hospitalization cost[3].

Nutritional status is certainly one of the independent factors that most influence postoperative results in elective surgeries[4]. In this context, nutritional assessments become essential in the preoperative period, to identify individuals at risk of developing complications related to nutritional deficiencies. The finding of malnourished patients or those at nutritional risk is essential to quickly institute adequate nutritional therapy in the preoperative period, with the aim of positively influencing the clinical evolution of patients in the postoperative period[5].

There are several methods for assessing hospitalized patients, such as anthropometric measurements, physical assessment, analysis of biochemical and immunological tests, as well as through clinical and dietary history, with specific advantages and disadvantages for each case. Thus, the association of several indicators is necessary to improve the precision and accuracy of the nutritional diagnosis. Anthropometric measurements, such as weight and height, are often used for nutritional assessment; however, being aware of the various physical limitations in which some surgical patients find themselves, they are not always possible to be performed[5].

Among the conventional anthropometric measurements, the assessment of the adductor pollicis muscle thickness (APMT) appears as an important technique to determine the muscle section of patients during hospitalization. It is an objective measurement, quick, simple to apply, low cost, and non-invasive[6,7]. However, despite these advantages, it has been little used as a parameter to diagnose nutritional status in clinical practice[7,8].

On the other hand, functional capacity, assessed by handgrip strength (HGS), is correlated with clinical complications and is a sensitive method to observe nutritional depletion in the short term[9]. As it is an easily reproducible parameter, it is more convenient than other malnutrition tracking tools and has gained considerable attention in recent years[10].

Both APMT and HGS can detect changes in nutritional status prior to other anthropometric and biochemical measurements, without the need to use sophisticated equipment or the application of equations, as in the case of arm muscle circumference[7]. In addition, currently, the most accurate techniques for assessing nutritional status are more expensive, less available[11], inadequate for repeated analyses, and less practicable in surgical patients, thus they are less available for this population[12].

Given the need for studies associating these tools with other markers of nutritional status, verifying the use of these parameters in identifying hospitalized individuals at a higher risk of developing postoperative complications related to malnutrition, the aim of this study was to evaluate the association between APMT and HGS with anthropometric parameters, subjective global assessment (SGA), and biochemical markers to diagnose the nutritional status of patients referred to surgery of the gastrointestinal tract and/or adnexal organs.

METHOD

Participants and study design

This was a cross-sectional study with all patients indicated for surgery of the digestive tract and/or associated organs from January 2013 to December 2015, admitted to Hospital das Clínicas, Federal University of Goiás, Brazil. The study was approved by the Research Ethics Committee of that hospital under opinion number 411.495 and CAAE: 17109013.7.0000.5078. All participants signed an informed consent form.

This study included patients of both genders, aged 19 years or older, admitted for surgery of the gastrointestinal tract and/or adnexal organs. Those who presented edema in the hands or upper limbs, who had a limb amputation, who were unable to be weighed or unable to answer the questionnaire were excluded.

A posteriori sample calculation was performed considering a Mann-Whitney test to compare two groups, with an α of 5% and an absolute frequency of individuals for the APMT and Body Mass Index (BMI) variables of our study, totaling an effect size of 0.73 and a testing power (1-β) of 82%.

Data collection protocol

Clinical, laboratory, and nutritional assessments were performed within 48 hours after hospital admission. Sociodemographic data (age, gender, and dominant hand) were collected through a previously structured questionnaire. Information regarding the diagnosis was obtained from clinical records.

Anthropometric assessment

Weight and height were measured on a digital scale (Filizola®; Filizola, São Paulo, Brazil) with a precision of 0.1 kg and on a stadiometer with precision in millimeters, respectively. Measurements were performed in a standardized way[11] for a later calculation of the BMI, and the results were classified according to the parameters of the World Health Organization[13] for adults and the Lipschitz parameters[14] for the elderly.

To assess the arm circumference (AC), a non-extendable measuring tape with a scale in millimeters (mm) was used, positioned at the midpoint of the right arm, between the acromial process of the scapula and the olecranon[15]. According to the age percentile table[16], patients were classified as malnourished when the AC values were < p5, eutrophic with a circumference from ≥ p5 to ≤ p95, and obese with AC > p95. To measure the triceps skinfold thickness (TST), the Lange Skinfold Calipter® adipometer was used and the final value was obtained by the average of three measurements recorded in mm, classified according to the percentile by age16. Patients with TST < p5 were considered malnourished, and those with ≥ p5 were considered eutrophic. The arm muscle circumference (AMC) was obtained using the equation AMC (cm) = AC (cm) - ϖ x (TST (mm) ÷ 10) and classified according to Frisancho[17]. Patients were classified as malnourished when the AMC values were < p5, as eutrophic with an AMC from ≥ p5 to ≤ p95, and obese with values above p95.

Thickness of the adductor pollicis muscle

APMT measurement was performed with the aid of an adipometer, Lange Skinfold Calipter®, exerting continuous pressure of 10 g/mm2 compressing the adductor muscle at the apex of an imaginary angle between the thumb and index finger[18]. The APMT measurement was performed with the patient seated, the arm flexed at approximately 90°

with the forearm and the hand resting on the knee. Patients were instructed to keep their hands relaxed. Three measurements were taken in the dominant hand and the mean, in millimeters, was used as the final APMT measurement[7]. To classify the measurements obtained, we considered > 13.4 mm as eutrophic values for APMT of the dominant hand and < 13.4 mm as malnutrition values[7].

Muscle strength

The assessment of HGS was performed according to the protocol established by Jamal et al.19 in the patient's dominant upper limb, using a portable mechanical dynamometer (Takei®; Scientific Instruments Co., Ltd., Tokyo, Japan) with 1-100 kgf variation and a precision of 0.5 kgf. The measurement was taken with the patient standing, with their elbow flexed at a 90° angle without resting it on the abdomen. Holding the dynamometer with the palm of the hand upwards, the patient would lower the arm, increasing the force so that, with the arm straight, they applied a maximum force. Three measurements were taken, with an average interval of twenty seconds and the largest measurement, in kilograms, was used for analysis. To classify the strength of the participants' handgrip, the cutoff points proposed by Schlussel[20] were used.

Subjective Global Assessment

The SGA was applied in the first 48 h of hospitalization, as proposed by Detsky *et al.*[21] and individuals were classified into three categories: i) well nourished, ii) mild and moderate malnourished, and iii) severely malnourished.

Biochemical tests

Serum albumin and creatinine results were obtained from medical records, from blood collections performed within 48 hours of hospitalization. Albumin values were classified as low when < 3.5 mg/dL, and adequate when ≥ 3.5 mg/dL, and creatinine was classified as low when < 0.6 mg/dL, adequate when ≥ 0.6 and ≤ 1.2 mg/dL, and high when > 1.3 mg/dL.

Statistical analysis

Data were tabulated with double typing and statistical analyses were performed using STATA version 14.0. The Shapiro-Wilk test was performed to verify the normality of continuous variables. Continuous variables were presented as mean and standard deviation and categorical variables as absolute and relative frequencies. Associations between categorical variables were assessed using Fisher's exact test. Differences between continuous variables were tested by Student's t test or Mann-Whitney test. The automated binary and multiple linear regression tests were performed using the backward method, in which included variables with $p<0.20$ and were adjusted for height, sex, and age for APMT, and for sex and age for HGS. Values were considered significant when $p<0.05$ in the final multiple model.

RESULTS

General features

Among the 66 selected individuals, ten were excluded because they were unable to be weighed or because they were unable to answer the questionnaire and/or were with a caregiver with little knowledge about the patient's history. 56 patients were evaluated, 58.93% adults and 41.07% elderly, with a mean age of 54.16 years (sd: 15.18). It was observed that 60.71% were female and that 46.43% of patients were admitted for bowel surgery, 25% and 10.71% for esophageal and gastric surgery, respectively, and 19.64% for adnexa organs (pancreas, gallbladder, and liver).

Regarding weight, the individuals were, on average, 61.44 kg (sd: 16.55) and had an average percentage of weight loss of 11.51% (sd: 10.27). Concerning the nutritional assessment through BMI, 19.64% of the volunteers were considered underweight and 26.59% overweight. Regarding AC, AMC and TST, 25%, 23.21%, and 12.50% were classified below the 5th percentile, respectively. It was found that 61.71% of patients had an APMT below the reference value and 41.07% had low HGS, with mean values of 12.18mm (sd: 5.04) and 23.16 kgf (sd: 8.58), respectively. When classifying the individuals through the SGA, 60.71% were well nourished and 39.29% were mildly to moderately malnourished, with no severe malnourishment.

APMT and HGS correlation with SGA and biochemical tests

Those patients with lower APMT and HGS, 44.12% and 47.83% respectively, were classified as malnourished in the SGA. Serum albumin below reference values was found in 46.67% of patients with low APMT values and in 47.62% with low HGS values. 6.06% and 4.55% of patients with low APMT and HGS had a low concentration of serum creatinine. No significant associations were found between APMT and HGS with SGA and biochemical tests (Table 1).

APMT and HGS correlation with anthropometry

Most individuals with low APMT were underweight when assessed by BMI, while overweight individuals had an APMT classified as normal (32.35 vs. 40.91%, p=0.003). Likewise, BMI, AC, and AMC were lower in individuals with reduced APMT when compared to those with normal APMT (BMI: 22.96±6.36 vs 26.28±4.53 kg/m^2, p= 0.001; AC: 26.54±4.74 vs 30.66±3.76 cm, p=0.001; AMC: 21.01±2.92 vs 24.20±3.34 cm, p<0.001).

When evaluating the HGS, AC and TST, a higher AC value was found in individuals with normal HGS when compared to those with low HGS (AC: 26.49±4.30 vs 29.32±4.84 cm, p=0.028; TST: 15.81±8.37 vs 20.86±9.40 mm, p=0.044). There was a higher percentage of individuals with low HGS classified as malnourished by the AMC assessment, while there was a lower percentage of malnourished individuals in those with normal HGS (39.13 vs 12.12%, p=0.046). When analyzing the relationship between HGS and APMT, it was found that HGS was lower in individuals with low APMT than in those classified as having normal APMT (20.86±7.92 vs 26.72±8.51 kgf, p= 0.011) (Table 1).

Association between APMT and HGS with anthropometric and biochemical tests

When the analysis was adjusted for height, age, and sex, a one-unit increase in normal weight, AC, and serum albumin was associated with higher APMT values (normal weight: 0.92 mm, 95%CI: 0.18;1.66, p=0.017; AC: 0.69 mm, 95%CI: 0.27;1.11, p=0.006; serum albumin 1.83mm, 95%CI 0.10; 3.57, p=0.039). On the other hand, the increase of one percentage unit in weight loss, reflected in a reduction of 0.85 mm in APMT (95%CI: -1.46; -0.25, p=0.008) and an increase of one unit of BMI was reflected in a reduction of 2.80 mm in APMT (95%CI: -4.73; -0.88, p=0.006).

When testing the association between anthropometric variables, biochemical tests, and the HGS measurements adjusted for sex and age, it was observed that the AC had a significant relationship in such that an increase of one unit in the AC promoted an increase of 0.734 kgf in HGS (95%CI: 0.30;1.17, p=0.02) (Table 2).

Table 1 – Association between nutritional status assessed by APMT and HGS and demographic and anthropometric variables in patients admitted to the surgical clinic (n=56). University Hospital, Goiânia, Goiás, Brazil, 2015.

Parameters	APMT				HGS		
	Total n=56	Low (<13.4mm) 34(60.71)	Normal (≥13.4mm) 22(39.29)	p-value	Low (<p10) 23(41.07)	Normal (≥p10) 33(58.93)	p-value
Age (years), mean (sd)	54.16(15.18)	56.67(14.57)	50.27(15.60)	0.124	52.83(13.78)	55.09(16.22)	0,587
Adult, n (%)	33(58.93)	19((55.88)	14(63.64)	0.592ж	16(69.57)	17(51.52)	0,270ж
Elderly, n (%)	23(41.07)	15(44.12)	8(36.36)		7(30.43)	16(48.48)	
Sex							
Female, n (%)	34(60.71)	23(67.65)	11(50.00)	0.187ж	15(60.71)	19(57.58)	0,592
Male, n (%)	22(39.29)	11(32.35)	11(50.00)		8(34.78)	14(42.42)	
Anthropometry							
Normal Weight (kg), mean (sd)	66.03(16.31)	63.40(17.20)	70.09(14.27	0.051*	63.69(12.43)	67.65(18.56)	0.409*
Current Weight (kg), mean (sd)	61.44(16.55)	57.31(17.13)	67.83(13.63)	**0.001***	59.31(13.46)	62.93(18.46)	0.414*
Weight loss (%),mean (sd)	11.51(10.27)	13.17(10.72)	8.62(9.06)	0.151*	11.01(9.10)	11.89(11.29)	0.979*
Height (m), mean (sd)	1.59(0.09)	1.58(0.09)	1.60(0.07)	0.290	1.61(0.07)	1.57(0.09)	0.103
BMI (kg/m²), mean (sd)	24.26(5.89)	22.96(6.36)	26.28(4.53)	**0.001***	22.80(4.86)	25.28(6.40)	0.127*
Underweight, n(%)	11(19.64)	11(32.35)	0	**0.003ж**	7(30.43)	4(12.12)	0.171ж
Eutrophic, n(%)	30(53.57)	17(50.00)	13(59.09)		12(52.17)	18(54.55)	
Overweight, n(%)	15(26.79)	6(17.65)	9(40.91)		4(17.40)	11(33.33)	
AC (cm), mean (sd)	28.16(4.80)	26.54(4.74)	30.66(3.76)	**0.001**	26.49(4.30)	29.32(4.84)	**0.028**
Malnourished (<p5), n(%)	14(25.00)	12(35.29)	2(9.09)	0.052ж	8(34.78)	6(18.18)	0.261ж
Eutrophic (≥p5;≤p95), n(%)	40(71.43)	21(61.76)	19(86.36)		15(65.22)	25(75.76)	
Obese (>p95), n(%)	2(3.57)	1(2.94)	1(4.55)		0	2(6.06)	
AMC (cm), mean (sd)	22.26(3.44)	21.01(2.92)	24.20(3.34)	<0.001	21.53(2.80)	22.78(3.78)	0.185
Malnourished (<p5), n(%)	13(23.21)	11(32.35)	2(9.09)	0.075ж	9(39.13)	4(12.12)	**0.046ж**
Eutrophic (≥p5;≤p95), n(%)	41(73.21)	22(64.71)	19(86.36)		14(60.87)	27(81.82)	
Obese (>p95), n(%)	2(3.57)	1(2.94)	1(4.55)		0	2(6.06)	
TST (mm), mean (sd)	18,79(9.26)	17.62(9.77)	20.58(8.29)	0.246	15.81(8.37)	20.86(9.40)	**0.044**
Malnourished (<p5), n(%)	7(12.50)	6(17.65)	1(4.55)	0.198ж	3(13.04)	4(12.12)	1.000ж
Eutrophic (≥p5;≤p95), n(%)	43(76.79)	26(76.47)	17(77.27)		18(78.26)	25(75.76)	
HGS (Kgf) mean (sd)	23.16(8.58)	20.86(7.92)	26.72(8.51)	0.011	-	-	-
APMT (mm) mean (sd)	12.18(5.04)	-	-	-	11.92(5.39)	12.36(4.85)	0.749
Subjective Global Nutritional Assessment							
Well-nourished, n(%)	34(60.71)	19(55.88)	15(68.18)	0.411ж	11.92(5.39)	12.36(4.85)	0.405ж
Malnourished, n(%)	22(39.29)	15(44.12)	7(31.82)		11(47,83)	11(33,33)	
Biochemical Assays							
Albumin (mg/dL), mean (dp)	3.58(0.60)	3.50(0.65)	3.69(0.51)	0.267	3.53(0.62)	3.62(0.59)	0.595
Low (<3.5 mg/dL), n(%)	21(40.38)	14(46.67)	7(31.82)	0.392ж	10(47.62)	11(35.48)	0.405ж
Adequate (≥3.5 mg/dL), n(%)	31(59.62)	16(53.33)	15(68.18)		11(52.38)	20(64.52)	
Creatinine (mg/dL), mean (dp)	0.88(0.40)	0.84(0.46)	0.88(0.30)	0.134*	0.89(0.54)	0.83(0.28)	0.902*
Low (<0.6 mg/dL), n(%)	2(3.64)	2(6.06)	0	0.364ж	1(4.55)	1(3.03)	1.000ж
Adequate (≥0.6 and ≤1.2 mg/dL), n(%)	48(86.27)	27(81.82)	21(95.45)		19(86.36)	29(87.88)	
High (>1.2 mg/dL), n(%)	5(9.09)	4(12.12)	1(4.55)		2(9.09)	3(9.09)	

Values presented as means and standard deviations, mean (sd); or absolute and relative frequencies, n (%). p-values obtained by unpaired Student's t-test (*U-Mann-Whitney test) or Fisher's exact ж test. BMI- Body Mass Index; AC- Arm Circumference; AMC- Arm Muscle Circumference; TST- Triceps Skinfold Thickness; HGS-Hand Grip Strength; APMT- Adductor Pollicis Muscle Thickness.
Source: research data.
Fonte: dados da pesquisa.

Table 2 – Association between nutritional status assessed by APMT and HGS and demographic and anthropometric variables in patients admitted to the surgical clinic (n=56). Goiânia, Goiás, Brazil, 2015.

Parameters	APMT				HGS			
	Binary β(IC95%)	p-value	Multiple* β(IC95%)	p-value	Binary β(IC95%)	p-value	Multiple** β(IC95%)	p-value
Normal Weight (kg)	0.07(-0.01;0.15)	0.075	0.92(0.18;1.66)	**0.017**	0.21(0.08;0.34)	0.002		
Current Weight (kg)	0.13(0.05;0.20)	0.001			0.21(0.08;0.34)	0.002		
Weight Loss (%)	-0.17(-0.33;-0.02)	0.030	-0.85(-1.46;-0.25)	**0.008**	-0.14(-0.43;0.15)	0.319		
BMI (kg/m²)	0.29(0.07;0.51)	0.010	-2.80(-4.73;-0.88)	**0.006**	0.32(-0.6;0.71)	0.101		
AC (cm)	0.56(0.32;0.80)	<0.001	0.69(0.27;1.11)	**0.006**	0.65(0.20;1.11)	0.006	0.73(0.30;1.17)	**0.002**
TST (mm)	0.14(-0.00;0.28)	0.054			-0.06(-0.31;0.19)	0.635		
AMC (cm)	0.08(0.04;0.11)	<0.001			0.14(0.08;0.20)	<0.001		
HGS (kgf)	0.27(0.13;0.41)	<0.001			-	-	-	-
APMT (mm)	-	-	-	-	0.78(0.37;1.20)	<0.001		
Albumin (mg/dL)	3.22(1.10;5.35)	0.004	1.83(0.10;3.57)	**0.039**	2.63(-1.39;6.66)	0.195		
Creatinine (mg/dL)	-0.31(-3.73;3.11)	0.857			-0.38(-6.26;5.50)	0.897		

Values presented in linear regression coefficient (β) and confidence interval (95%CI). The multiple linear model was selected using the automated backward method, in which variables with p<0.20 were included. * Adjusted by height, age, and gender or ** by gender and age. The multiple linear model for APMT presented an adjusted R^2 of 52.58% and for HGS of 62.81%. BMI- Body Mass Index; AC- Arm Circumference; AMC- Arm Muscle Circumference; TST- Triceps Skinfold Thickness; HGS-Hand Grip Strength; APMT- Adductor Pollicis Muscle Thickness.

Source: research data.

DISCUSSION

APMT is a measurement that objectively assesses the thickness of the adductor pollicis muscle and is easy to perform due to its anatomical conformation and muscle flatness[16,22]. The adductor pollicis muscle, as it suffers minimal interference from subcutaneous fat, can be evaluated and its thickness used as a muscle mass marker[7,23-25]. In our study with surgical patients, although we did not directly assess total muscle mass, we observed that APMT was reduced for approximately 60% of patients and was directly associated with measurements that assess nutritional status such as normal weight, AC, and plasma albumin, but not with AMC and TST. In a study carried out by Bragagnolo *et al.*[7], APMT was also directly correlated with anthropometric measurements that do not specifically measure muscle mass, including AC. However, unlike our results, in a study conducted by De Oliveira *et al.*[25], evaluating 143 kidney disease patients, APMT was significantly correlated with markers that reflect the condition of the patent's muscular compartment, such as AMC and arm muscle area, but not with parameters that estimated fat mass.

In the present study, no association was shown between APMT and HGS and SGA, which can be explained by the fact that SGA comprises subjective and objective aspects of nutritional status, including clinical history and physical examination components. SGA, initially proposed to evaluate surgical patients, is currently used in individuals with other pathologies, mainly because it does not require equipment for its application26. The SGA considers weight loss in the last six months, changes in diet, gastrointestinal changes, functional capacity, metabolic stress, in addition to physical examination. However, one of the main disadvantages of this method is the tendency to underestimate the proportion of malnourished patients when compared to anthropometric results[27], which was observed in this study. Another issue is that, as it is a subjective method, the experience of the evaluator can also influence the accuracy of the nutritional diagnosis and there is also the fact that the patient may omit, or not remember, information contained in the first stage of the method, and the results found by the SGA may differ from those found by other objective methods of nutritional assessment[28].

APMT was also inversely associated with weight loss. Patients classified as having reduced APMT had a higher percentage of weight loss in the last six months, which is justified by deficits not only of adipose tissue, but also of muscle tissue. A similar result was obtained by De Oliveira *et al.*[25] and Bragagnolo *et al.*[7], in which APMT was positively correlated with the percentage of weight loss, demonstrating specificity in the assessment of the nutritional status of surgical patients.

Interestingly, however, APMT was also inversely associated with BMI, suggesting that individuals with a low BMI have higher APMT values. This result differs from De Oliveira *et al.*[25] and Melo and Silva[12] who verified a direct correlation between these parameters. When evaluating this paradox, it is necessary to remember that BMI is often criticized for not distinguishing between fat mass and lean body mass and for ignoring the distribution of body fat. This fact limits the ability of the BMI to reveal the muscle mass of individuals[29]; a fact that can be performed by measuring the APMT. This result demonstrates that BMI should not be prioritized as an indicator of nutritional status in hospitalized individuals, especially if it is the only parameter used in patient assessment[30].

The nutritional status of hospitalized patients can be underestimated due to the presence of edema, decreasing the accuracy of anthropometric measurements, such as weight and circumferences. Therefore, visceral serum proteins, such as albumin, have traditionally been used in clinical practice as markers of nutritional status. In the present study there was a direct association of APMT with serum albumin; however, although the concentration of this protein is a good index of protein-energy malnutrition, indicating, when reduced, a limited supply of energy and protein substrate, it is known that factors, in addition to nutritional, may modify their concentrations such as hydration status, inflammation, and liver disease. Thus, as an isolated parameter, the determination of albumin does not characterize the general condition of the individual and, for this reason, it is necessary to use an association of several indicators to determine the nutritional diagnosis of the patient[31].

The lesser APMT, in relation to the proposed reference value[7], together with other variables and nutritional assessment methods, is capable of estimating the loss of muscle mass, since the adductor pollicis muscle is consumed during catabolism and disuse. As it is capable of revealing changes in body muscle composition, APMT identifies both the risk of malnutrition in patients during hospitalization and the recovery of the nutritional status of non-walking or bedridden patients[24,32].

Another aspect to be discussed is that the accuracy and reliability of anthropometric measurements are influenced by many variables, such as: equipment, technical skill, individual cooperation, and a variety of reference standards[32]. However, the ease of measuring APMT in hospitalized patients may contribute to the determination of clinical outcomes, as described by Caporossi *et al.*[23] and Ghorabi *et al.*[33], in which reduced APMT in critically ill patients was associated with a higher mortality and longer length of stay in the intensive care unit. In surgical patients, in a study carried out with 361 individuals, APMT, although showing low sensitivity, was highly specific (specificity greater than 90%) for predicting malnutrition34. Moreover, Gonçalves *et al.*[35] found that, in patients undergoing elective cardiac surgery, there was a significant association between APMT and infectious complications in the postoperative period, demonstrating that APMT is an important indicator of nutritional status and predictor of surgical risk.

In the present study, we found that there was a significant association of HGS with APMT, but this fact was not found when comparing APMT with HGS, unlike the research carried out by Budziareck *et al.*[36], which can be attributed to the assessment in healthy individuals, differently from our work. These authors, evaluating 300 individuals, aged between 18 and 90 years old, observed a strong relationship between APMT and HGS, even after adjusting for sex, age, and BMI. According to these same authors, HGS values varied with age and gender, which highlights the importance of using HGS and APMT combined as a method for nutritional assessment, in addition to the need to use specific reference values for different populations.

Furthermore, HGS was positively associated with AC. It is noteworthy that, although we did not observe an association with other anthropometric measurements evaluated, HGS is considered an effective method to verify the nutritional status of hospitalized individuals[37]. Olguín *et al.*[38] followed 125 patients hospitalized for medical and surgical conditions. After thirty days of hospitalization, 28.8% of the volunteers had deteriorated functional status and the group with the highest percentage of patients with severe malnutrition had lower HGS.

Limitations

The present study has as limitations the cross-sectional design, and since the anthropometric measurements were measured only once it is not possible to determine the causal relationship between the variables. Furthermore, the evaluation of patients admitted for surgeries of the gastrointestinal tract and/or adjacent organs did not consider other surgical markers and there was the absence of C-reactive protein results to verify the presence of an inflammatory or infectious process.

CONCLUSION

There is a positive association between HGS and AC and between APMT, normal weight, AC, and serum albumin, as well as an inverse association between APMT, percentage of weight loss, and BMI in surgical patients, even after adjustment for height, sex, and age. These associations demonstrate that APMT and HGS can complement nutritional assessment and speed up early intervention in these patients, not requiring a single parameter for diagnosis and nutritional monitoring.

It is recommended that prospective studies be carried out to determine whether changes associated with APMT and HGS can be detected after nutritional intervention and that a greater of the number of hospitalized patients be evaluated, in order to provide more robust results.

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