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Original article

Hand grip strength as predictor of undernutrition in hospitalized patients with cancer and a proposal of cut-off

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SUMMARY

Background & aims: Hand Grip Strength (HGS) has been proposed as an indicator of nutritional status, being an easy and non-invasive method and presenting high reliability among evaluators. However, there are no cut-off points. To compare HGS with objective methods of nutritional assessment and to propose a cut-off point for its use as a predictor of malnutrition in cancer patients.
Methods: This is a retrospective study with 76 patients (52.6% females, 56.8 ± 16.6 years old) admitted with a diagnosis of cancer in hospitals of Belo Horizonte (MG, Brazil). We evaluated the HGS of the dominant hand, Body Mass Index (BMI), calf circumference (CC), and arm circumference (AC), using the *Receiver Operator Characteristic* (ROC) curve analysis, being the Patient-Generated Subjective Global Assessment (PG-SGA) the reference method. Statistical tests were performed according to the distribution of the variables, verified by the Shapiro–Wilk test. The level of significance adopted was 5%.
Results: The HGS was higher in men ($p = 0.001$) and adults ($p = 0.002$). The HGS presented a better performance in the prediction of malnutrition (AUC = 0.766, 95% CI = 0.656–0.936) compared to the anthropometric indicators, with a cut-off point of 32.5 kg (sensitivity of 90.5% and specificity of 61.5%). The prevalence of malnutrition was 82.9% and 81.6% for PG-SGA and proposed cut-off point for HGS, respectively.
Conclusions: The HGS was more sensitive to identify individuals at risk of malnutrition compared to other recognized indicators of nutritional status, indicating its application in a hospital setting with cancer patients.

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1. Introduction

Malnutrition is prevalent in individuals with cancer [1] due to the presence of metabolic disorders related to the tumor, inadequate food intake and the occurrence of nutritional impact symptoms (NIS) caused by the treatment [1,2]. Their occurrence in cancer patients is associated with increased risk of complications, longer hospital stays, less tolerance and response to treatment, low survival rates, and decline in quality of life [1,3].

The Oncology Nutrition Dietetic Practice Group of the American Dietetic Association [4] and the American Society for Parenteral & Enteral Nutrition (ASPEN) [5] recommend the Patient-Generated Subjective Global Assessment (PG-SGA) for the diagnosis of malnutrition in cancer patients, however, there is no consensus on a universally accepted method to assess nutritional status in these individuals [2]. The European Society for Clinical Nutrition and Metabolism (ESPEN) recommends the regular evaluation of weight change, Body Mass Index (BMI) and food intake, which can be obtained directly or through tools such as Nutritional Risk Screening 2002 (NRS-2002) and Mini Nutritional Assessment (MNA) [2].

On the other hand, the evaluation of the Hand Grip Strength (HGS) has been recommended [6], since it is considered an indicator of nutritional status and allows the verification of variation before the occurrence of anthropometric and biochemical changes [7]. It is recognized as a non-invasive, economical, portable and easy-to-use method [8]. In addition, it is highly reliable among evaluators [9], may be more convenient than the other nutritional assessment tools currently used and is gaining attention in recent years [10]. Authors have reported association between HGS and nutritional status categories according to PG-SGA in patients with unresectable lung cancer [8], however we have detected in our literature search only one article published by Hu et al. (2018) [10], which compared the nutritional assessment methods in order to detect the accuracy of HGS in individuals with cancer.

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In view of the above, this study aimed to compare the Hand Grip Strength (HGS) with objective methods of nutritional diagnosis and to propose a cut-off point for its use as a predictor of malnutrition in individuals with cancer.

2. Materials and methods

2.1. Sample

This retrospective study included individuals aged over 20 years, hospitalized with a diagnosis of cancer in hospitals in the city of Belo Horizonte, Minas Gerais, Brazil, from February to July, 2018. Inclusion criteria were patients with complete data of nutritional assessment and evaluation of the HGS. There were no restrictions on cancer location, step and treatment. These data were obtained through electronic medical records used by the institutions.

The study was approved by the Human Research Ethics Committee of the Universidade Federal de Viçosa (UFV) (2.760.901/2018) and by the Human Research Ethics Committee of the Universidade Federal de Minas Gerais (UFMG) (2.466.173/2018), and was conducted in accordance with the guidelines of the Declaration of Helsinki.

2.2. Diagnosis of malnutrition

Two trained researchers evaluated the nutritional status and Hand Grip Strength (HGS) of the subjects. The nutritional status was evaluated by the Patient-Generated Subjective Global Assessment (PG-SGA) and by anthropometry. The PG-SGA used was the adapted and validated model for the Brazilian population [11,12]. Malnourished individuals were those of stages B (moderate or suspected malnutrition) and C (severely malnourished) [13]. Patients classified in stage A of the PG-SGA were considered as well nourished.

Regarding anthropometric measures, the weight was obtained with the individual bare, unadorned and through digital scale (Model: Personal, Filizola®, Brazil). Stature was reported by the patient or family member. The Body Mass Index (BMI), in kg/m^2 was calculated and displayed as malnutrition when BMI <18.5 kg/m^2 for adults [14] and BMI ≤ 23 kg/m^2 for the elderly [15]. We defined as adults individuals between 20 and 59 years old and elderly those over 60 years old. The calf (CC) and arm circumferences (AC) were measured with millimeter tape, flexible and inelastic, without tissue compression. The calf circumference was evaluated with the tape placed in the horizontal position at the maximum circumference of the calf and the values under 31 cm were classified as malnutrition [16]. Arm circumference was measured at the midpoint between the acromion process of the scapula and the olecranon, with the arm positioned parallel to the trunk. For their classification, it was used the arm circumference adequacy of $<90\%$, obtained according to the equation AC (%) = AC obtained (cm) x 100/ 50th percentile of AC. The reference adopted was the 50th percentile according to age and sex of the population [17].

2.3. Hand Grip Strength (HGS)

The Hand Grip Strength (HGS) was measured from the dominant hand using the digital dynamometer (Model EH101, Camry®, China). The individuals were sitting with their shoulders pressed, elbow flexed 90° and forearm and wrist in neutral position [9]. Patients were instructed to perform three maximal compressions, with brief pauses between measurements. Finally, the mean value was calculated.

2.4. Statistical analysis

Statistical analysis was performed using the *SPSS Statistics* program, version 21.0 (SPSS, Inc., Chicago, USA). The distribution of the variables was verified by the Shapiro–Wilk test. Data were expressed as frequencies, mean (SD) or median and interquartile ranges, depending on the distribution of the variable.

To compare the nutritional status and HGS variables according to gender, age, and PG-SGA categories, it were performed the Student's t-test or Mann–Whitney test or Analysis of Variance (ANOVA) complemented by the Tukey test, according to the type and distribution of the variable. The frequency of malnutrition between groups was assessed using Pearson's chi-square test or Fisher's exact test. Multivariate linear regression analysis was conducted to examine the associations between HGS, PG-SGA categories, sex, and age. The final model included variables significantly associated with HGS in bivariate correlation analyzes. To compare malnutrition and HGS diagnostic methods, the *Receiver Operator Characteristic* (ROC) curve was analyzed using PG-SGA as a reference. The level of significance adopted in all analyzes was 5%. Thus, the power of the study was 93.6%, considering two groups of nutritional status, according to the PG-SGA [malnourished (n = 63) and well nourished (n = 13)], mean ± standard deviation of HGS of these groups (18.9 ± 9.8 kg and 31.5 ± 12.4 kg, respectively) and a significance level of 5%.

3. Results

Of the 80 patients eligible for participation, 3 did not present PG-SGA and 1 was without calf circumference. Thus, 76 individuals were evaluated, with a mean age of 56.8 years old (±16.6 years old), ranging from 21 to 87 years. The sample consisted of 52.6% of women (n = 40) and 50% of elderly (n = 38) (Table 1).

When the averages were analyzed, the anthropometric indicators were similar between the sexes and age groups. However, as expected, HGS was statistically higher in men ($p = 0.001$) and adults ($p = 0.002$) (Table 2).

The multivariate linear regression analyses showed that HGS levels were negatively associated with the PG-SGA categories ($\beta = 0.211$, $p = 0.037$) when adjusted for sex and age (Fig. 1). In addition,

Table 1
Characteristics of the sample. Belo Horizonte, Brazil, 2018.

Variable	n (%)
Gender	
Women	40 (52.6)
Men	36 (47.4)
Age group	
Adults	38 (50.0)
Elderly	38 (50.0)
Type of cancer	
Hematologic	49 (64.4)
Breast	5 (6.6)
Stomach	5 (6.6)
Colorectal	4 (5.3)
Pancreatic	3 (4.0)
Others	10 (13.1)
Metastasis	
Yes	14 (18.4)
No	62 (81.6)
Treatment	
Chemotherapy	44 (57.9)
Surgical	5 (6.6)
Chemotherapy and bone marrow transplant	4 (5.3)
Chemotherapy, radiotherapy and surgical	2 (2.6)
Chemotherapy and radiotherapy	1 (1.3)
Bone marrow transplant	5 (6.6)
Palliative care	7 (9.2)
Recent diagnosis/Treatment not defined	1 (1.3)
Uninformed	7 (9.2)

Other types of cancer: prostate, head, bones, ovary, lung, kidney and bile ducts.

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Table 2
Anthropometric indicators and Hand Grip Strength (HGS) of hospitalized cancer patients, by sex and age group (n = 76). Belo Horizonte, Brazil, 2018.

Indicators	Total	Men	Women	p	Adults	Elderly	p
BMI (kg/m ^{2})	24.8 (21.6–27.4)	25.0 (20.9–27.7)	24.7 (21.7–27.3)	0.775	24.7 (20.6–26.9)	25.2 (22.4–27.9)	0.338
CC (cm)	35.1 (4.4)	35.7 (4.2)	34.6 (4.5)	0.274	35.7 (3.7)	34.6 (4.9)	0.284
AC (cm)	28.3 (25.4–31.3)	28.8 (26.1–31.8)	28.0 (25.0–30.9)	0.335	28.2 (25.3–31.9)	28.3 (25.3–31.0)	0.984
HGS (kg)	18.2 (12.5–27.4)	24.4 (17.8–32.9)	15.0 (11.6–21.5)	0.001∗	24.1 (16.0–32.4)	14.3 (11.1–23.7)	0.002∗

Data expressed as mean (SD) and median (p25-p75). P values of the Student t test and Mann–Whitney test, according to the distribution of the data. ∗p values less than 0.05 in the statistical tests. AC: Arm Circumference; BMI: Body Mass Index; CC: Calf Circumference; HGS: Hand Grip Strength.

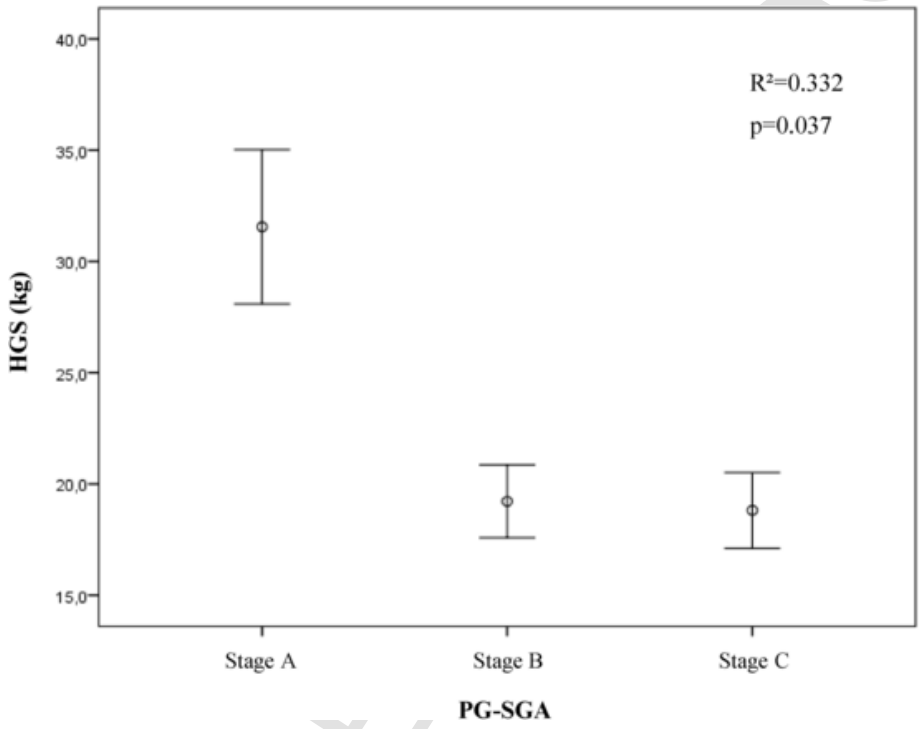

Fig. 1. Hand Grip Strength (HGS) of hospitalized cancer patients (n=76) according to the classification of Patient-Generated Subjective Global Assessment (PG-SGA). Belo Horizonte, Brazil, 2018. Data expressed as mean ± 1 standard error. P value in the Multivariate Linear Regression, adjusted for sex and age. Stage A: well nourished. Stage B: moderate or suspected malnutrition; Stage C: severely malnourished.

HGS values were statistically higher in patients in stage A (well nourished), compared to those in stage B and C (p = 0.003 and p = 0.001, respectively) (unpublished data).

Interestingly, the ROC curve was analyzed to confirm the sensitivity of HGS and anthropometry in relation to PG-SGA. AUC was 0.796 (95% CI = 0.656–0.936) for HGS, 0.585 (95% CI = 0.404–0.766) for AC, 0.563 (95% CI = 0.405–0.722) for CC and 0.495 (95% CI = 0.326–0.665) for BMI (Fig. 2). HGS, CC and AC were good indicators for the diagnosis of malnutrition, since they presented AUC >0.5. However, HGS obtained higher AUC, being the only statistically significant (p = 0.001), that is, the method that obtained the best performance in the prediction of malnutrition. The HGS value of 32.5 kg obtained high sensitivity and good specificity (90.5% and 61.5%, respectively) (Table 3).

The prevalence of malnutrition ranged from 19.7% to 82.9% when diagnosed by CC and PG-SGA, respectively. According to the PG-SGA score, 53.9% of the patients required critical nutritional intervention. Considering the cut-off point of 32.5 kg for HGS, 81.6% of study participants were found to be malnourished, similar to that determined by PG-SGA. The frequency of malnutrition, according to the cut-off of HGS presented statistical difference between the sexes (p = 0.016). In addition, the frequency of malnutrition also presented a statistical difference between the age groups (p = 0.024), when evaluated by the BMI (unpublished data).

4. Discussion

The first relevant result of our study was the association of the HGS with the PG-SGA categories, regardless of gender and age. The HGS was higher among well-nourished individuals than those who had some degree of malnutrition (moderately malnourished or at risk of malnutrition and severely malnourished). The same was observed in patients hospitalized for different reasons, where PG-SGA category A individuals had Arm perimeter different from B categories (p < 0.001) and C (p < 0.001), but these categories of malnutrition were similar (p = 0.285) [18].

The HGS is considered a marker of nutritional status because it reflects deprivation and early nutritional depletion [10]. The low strength and nutritional risk or malnutrition identified by PG-SGA in cancer patients has been associated with increased length of hospital stay [19].

A second important result was identified at the ROC curve analysis, in which the HGS was the method that performed better in predicting malnutrition. The multicenter study conducted in Chinese hospitalized with cancer (n = 11,314), aged between 18 and 90 years, obtained AUC ranging from 0.615 to 0.640 for sex and age groups (adult

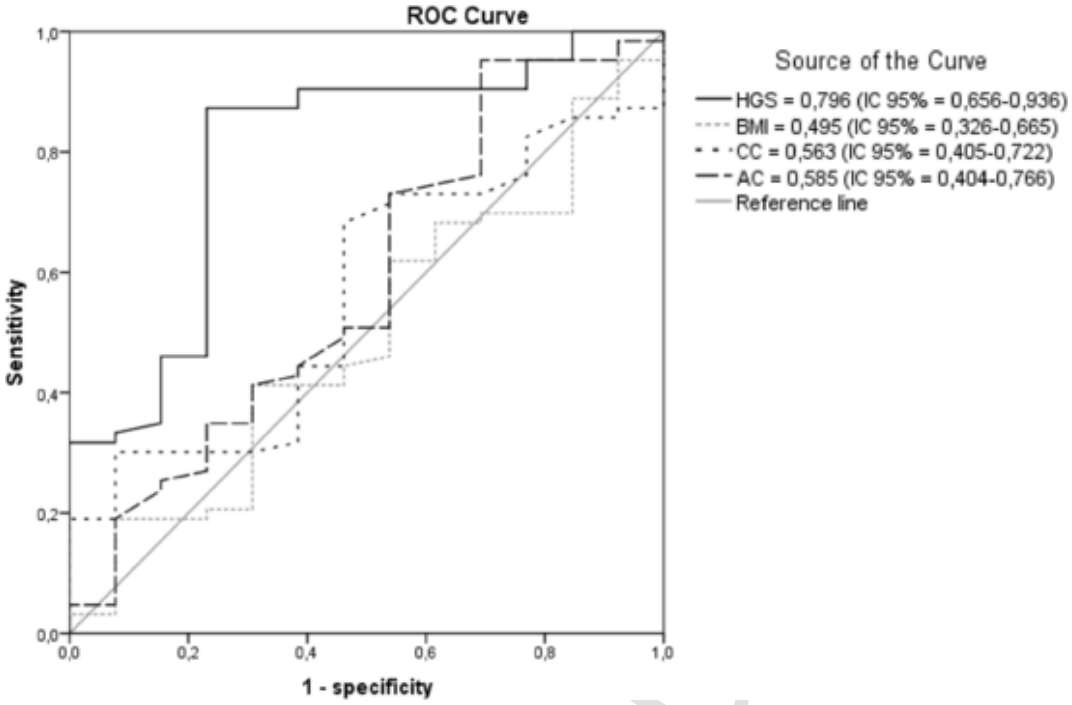

Fig. 2. ROC curve of indicators used as predictors of malnutrition in relation to the Patient-Generated Subjective Global Assessment (PG-SGA). Belo Horizonte, Brazil, 2018. HGS (p = 0,001), BMI (p = 0,956), CC (p = 0,473) and AC (p = 0,338). AC: Arm circumference; BMI: Body Mass Index; CC: Calf circumference; HGS: Hand grip strength.

Table 3
Cut-off points, sensitivity, and specificity of the HGS for malnutrition prediction in hospitalized cancer patients (n = 76). Belo Horizonte, Brazil, 2018.

HGS		
Cut-off	Sensitivity (%)	Specificity (%)
27.9	87.3	76.9
28.4	87.3	69.2
30.5	87.3	61.5
32.5 [a]	90.5	61.5
32.7	90.5	46.2
32.9	90.5	38.5
33.4	90.5	30.8

[a] Cut-off point with the best sensitivity and specificity values, adopting the Patient-Generated Subjective Global Assessment (PG-SGA) as the reference method. HGS: Hand Grip Strength.

men, adult women, elderly men and elderly women), but detected, however, low values of sensitivity and specificity, indicating a low diagnostic accuracy of HGS [10]. On the other hand, the authors used the HGS's non-dominant hand and only the stage C (severe malnutrition) PG-SGA (22.3% and 37.8% of adults and elderly, respectively) for construction of the ROC curve. As shown in our study, individuals classified with some degree of malnutrition by PG-SGA (stage B and C) had similar HGSs, which justifies the use of both categories in the construction of the ROC curve.

The European Working Group on Sarcopenia in Older People 2 (EWGSOP2) [20] recommends the cut-off points for HGS proposed by Dodds et al. (2014) [21] for the sarcopenia diagnosis. These values are lower than the cut-off point proposed in the present study (≤27 and 16 kg for men and women, respectively). The ideal tool would be 100% sensitive and specific [22]. However, malnutrition detection instruments must have high sensitivity over specificity [2], because the need to correctly classify all patients at nutritional risk is more important than the misclassification of malnourished as well-nourished individuals [22]. Thus, to determine the cut-off point for HGS, we assumed the value that presented highly sensitive and had a good specificity. The value proposed as a cut-off point was 32.5 kg, regardless of sex and age.

In the present study, we still observed a higher frequency of malnourished individuals when using PG-SGA (82.9%), and this was lower with the use of anthropometric indicators. Differences in the prevalence of malnutrition among cancer patients were also identified: depending on the method used, 50% when using PG-SGA, 38.9% for AC and 5.5% for BMI [23]. On the other hand, the proposed cut-off point for HGS detected the frequency of malnutrition close to PG-SGA.

Finally, HGS was different between sexes and age group, as expected. Likewise, when comparing healthy individuals, men presented higher values of HGS compared to women and a significant decrease after 40 and 50 years of age for men and women, respectively [24]. Patients at the hospital admission of the cardiology, endocrinology, hepatology, gastroenterology, nephrology, urology and orthopedic wards also presented such difference between sex and decrease with the advancement of age [25].

Our study has limitations. Our sample was heterogeneous in terms of type of cancer, diagnostic and treatment time, because our goal was to assess whether the HGS applies to all cancer patients. Still, the size of the sample made it impossible to divide into sex and age groups, despite the power of the study with 93.6% confirming reliability of our results.

In conclusion, the Hand Grip Strength (HGS) was the most sensitive method to identify individuals at risk of malnutrition compared to anthropometric indicators. Thus, HGS is an alternative for the detection of malnutrition in cancer patients when it is impossible to use other methods, such as PG-SGA, and the proposed value of 32.5 kg showed high sensitivity and good specificity.

Statement of authorship

NPM was responsible for collecting and analyzing data, interpreting the results, and writing the article. TAB was responsible for data collection and contributed to the final review of the article. BSF, ESA and CAO contributed in the data collection and final review of the arti-

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cle. HHMH, ECGS and SSP led the data analysis and interpretation of the results, helping to the writing and final revision of the article. COBR was responsible for the research, collection and analysis of data, interpretation of the results and writing of the article.

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Declaration of Competing Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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