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Original article

Diagnostic accuracy of handgrip strength in the assessment of malnutrition in hemodialyzed patients

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SUMMARY

Background & aims: Parameters with diagnostic accuracy to malnutrition assessment may be a challenge for patients in hemodialysis (HD). Thus, the objective of this study was to verify the accuracy and cutoff of handgrip strength (HGS) in nutritional assessment.
Methods: Validation study of diagnostic tests. Cutoff to malnutrition was investigated by the ROC curves, using as reference standard the subjective global assessment (SGA), nutritional risk screening 2002 (NRS 2002) and malnutrition-inflammation score (MIS). The association of HGS with: phase angle (PA), body mass index, percentage of fat mass, fat-free mass (FFM), was verified by multiple linear regression, $P < 0.05$.
Results: 138 patients were evaluated (85 men), mean 55.4 ± 15.2 years. The area under the curve of the HGS showed moderate accuracy in women (SGA = 0.818; MIS = 0.834; NRS 2002 = 0.882) and low accuracy in men (SGA = 0.646; MIS = 0.606; NRS 2002 = 0.620). Cutoff values of HGS for the diagnosis of malnutrition, according to the reference standard were: <18 kg for women and <28.5 kg for men. The women classified as malnourished by HGS had lower values of PA ($\beta = -1.00$), FFM ($\beta = -3.15$) and MAC ($\beta = -2.80$), while malnourished men had lower values of FFM ($\beta = -4.35$), MAC ($\beta = -1.71$) and MAMC ($\beta = -1.28$).
Conclusion: HGS was accurate in the diagnosis of malnutrition in women in HD, and provided consistent results of association with most of the nutritional parameters, for both genders.

1. Introduction

Malnutrition is common in patients with chronic kidney disease,[1] including those who perform hemodialysis (HD),[2,3] and it has been identified as an important risk factor for complications and mortality.[1,4]

In the absence of a gold standard technique for assessing nutritional status, one has sought to identify new methods able to accurately diagnose malnutrition,[3,5,6] but the validity of each of them is still under debate.[7]

The assessment of muscle reduction may be one good indicator for this diagnostic,[6,8] because malnourished patients have depleted lean body mass and consequently reduced muscle strength.[9,10]

Handgrip strength (HGS) is a non-invasive, simple and fast parameter for muscle strength assessment[11] that can be reliable in renal patients.[9–11]

In the scientific literature, there are only two studies that aimed to evaluate HGS as a parameter for nutritional assessment in hemodialyzed patients. One of them assessed its association with nutritionals parameters,[6] while the other also assessed the diagnostic accuracy of HGS.[12]

Considering the small amount of research on this topic, the aim of this study was to evaluate the diagnostic accuracy of HGS and

Abbreviation: HGS, handgrip strength; AUC, area under the curve; BIA, bioelectrical impedance analysis; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference; PA, phase angle; HD, hemodialysis; BMI, body mass index; FFM, fat-free mass; % FM, percentage of fat mass; ROC, receiver operator characteristics.

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cutoff in the malnutrition assessment of hemodialyzed patients, using the subjective global assessment (SGA), the malnutrition-inflammation score (MIS) and the nutritional risk screening 2002 (NRS 2002) as reference standard, and evaluate the association of HGS with phase angle (PA), body mass index (BMI), percentage of fat mass (%FM), fat-free mass (FFM), mid-arm circumference (MAC) and mid-arm muscle circumference (MAMC).

2. Subjects methods

2.1. Patients

The validation study of the diagnostic tests was carried out with patients at two clinics for renal patients in the region of Florianópolis, Santa Catarina, Brazil. Patients considered eligible were those above 19 years old, from both genders, and who performed HD three times a week between April and August 2011. The non-inclusion criteria were: onset of dialysis less than three months before, BMI >34 kg/m^2, amputated or atrophied upper/lower limbs, use of cardiac pacemaker, current cancer diagnosis, sequel of cerebrovascular accident, inability to understand and communicate with the interviewer, or hospital admission for any reason during the evaluation. Of the 163 patients eligible for the study, 25 refused to participate of the research.

Demographic data, time of initiation of the dialysis, comorbidities and laboratory tests were obtained from medical records of the patients.

The assessments were performed at the same time (after the HD session), and the laboratory data used were those obtained more recently, and the time interval in relation to the other information was shorter than 30 days. The investigation was approved by the Research Ethics Committee of the Federal University of Santa Catarina, and all participants signed an informed consent document.

2.2. Handgrip strength

HGS was measured using a Saehan® hydraulic hand dynamometer model SH 5001 (Saehan Corporation – Yangdeok-Dong, Masan, Korea) with a scale of strength up to 90 kg.

The patients were instructed about the use of the dynamometer; explanations and demonstration were given on the need to tighten the handle to its full strength. At the moment of assessment, each participant was seated with hips and knees at 90° of flexion, adducted shoulder close to the trunk, flexed elbow at 90° with the forearm in neutral position (between supination and pronation) and wrist between 0° and 30° of extension and 0°–15° of ulnar deviation.[11]

HGS was evaluated on the arm side without vascular access. Three measurements were performed, with the period of contraction maximum continuous of three seconds. For the analysis, the highest value of the three measurements was taken into consideration.[9]

2.3. Phase angle

Bioelectrical impedance analysis was performed to obtain the measurements of resistance (R) and reactance (Xc), using calibrated Biodynamics® portable tetrapolar equipment, model 310 (Biodynamics Corporation – Seattle, Washington, USA), which applies a current of 800 μA and a single frequency of 50 kHz.

The patients were evaluated for approximately 20 min after the HD procedure, on the side of the arm without vascular access.[13,14] R and Xc were used to calculate PA (BAUMGARTNER; CHUMLEA; ROCHE. 1988): phase angle $(^\circ) = \text{arc tangent}\ [(Xc(\Omega)/R(\Omega)) \times (180/\pi)]$.[15]

2.4. Nutritional screenings

SGA was carried out as recommended by Detsky et al.[16] The participants were classified as A-well nourished, B-moderately (or suspected of being) malnourished or C-severely malnourished. The patients in categories B and C were grouped for statistical analysis. The MIS was performed according to Kalantar-Zadeh et al.,[1] in that patients were classified as well nourished (<6) and malnourished (≥ 6).[12,17] NRS 2002 was evaluated according to Kondrup et al. and the patients were classified in: without nutritional risk (<3) or at nutritional risk (≥ 3).[18]

2.5. Anthropometry

The anthropometric assessments included dry weight (kg), height (m), MAC (cm) and skinfold thickness (mm), and they were measured after the HD session. BMI (kg/m^2), %FM, FFM (kg) and MAMC (cm) were obtained. MAC and skinfold thickness were measured on the side of the arm without vascular access. All data were collected by one dietitian (MFG), who standardized procedures to measure the height, MAC and skinfold thickness according to Lohman.[19]

Weight was measured using a Marte® electronic weighing scale (Marte Balanças e Aparelhos de Precisão Ltda – Santa Rita do Sapucaí, MG, Brazil). Height was measured with a portable stadiometer Sanny® (American Medical do Brasil – São Bernardo do Campo, SP, Brazil). Based on these measurements, BMI was calculated.[20]

%FM was determined by Siri's formula[21]: $\%FM = 4.95/\text{body density} - 4.50 \times 100$. To calculate body density, the equation of Durnin and Womersley[22] was used: $\text{Body Density} = (AB)\ \text{Log}\ \Sigma\ 4$ skinfolds, where A and B are coefficients related to age and gender.

For the evaluation of skinfolds thickness (biceps, triceps, subscapular and suprailiac),[19] a Lange® calliper (Beta Technology Incorporated Cambridge, Maryland, USA) was used, and the mean of three measurements was considered. After calculation of %FM, FFM was obtained by subtracting the fat mass of the total weight.

MAC was measured with a tape, sheet steel Cescorf® (Cescorf Equipamentos para Esporte Ltda – Porto Alegre, RS, Brazil), according to Frisancho.[23] With the measures of triceps skinfold and MAC, MAMC[23] was calculated.

2.5.1. Laboratory tests

All blood samples were collected in the pre-dialysis period, with exception of urea, measured pre and post dialysis. Analysis of serum albumin was performed by the bromocresol green method and to the total binding capacity of iron, by cromazurol-B. The urea for calculation of Kt/V was obtained by the urease-CDC method.

The dialysis adequacy (Kt/V) was calculated by the formula $[Kt/V = -\text{Ln}\,(R - 0.03) + (4 - 3.5 \times R) \times UF/W]$, where Ln is the natural logarithm, R is the ratio urea pre/post dialysis, UF is the value removed in the ultra-filtrate and W is the weight (kg) post dialysis.[24]

2.6. Statistical methods

Data were analyzed using Data Analysis and Statistical Software (STATA, version 11 for Windows – Stata Corporation, College Station, TX, USA). Description of the sample was performed by absolute and relative frequencies, means and standard deviations or medians and inter-quartile ranges of the evaluated variables. To check the difference between these variables according to gender, the Chi-square test was used for categorical variables and the Student's *t*-test or Mann–Whitney U test was used for numerical variables.

Pearson or Spearman correlation was performed to assess the relationship between the HGS and the other nutritionals parameters. A correlation was considered to be weak when the value ranged from 0 to 0.29; moderate, from 0.30 to 0.69; and strong, from 0.70 to 1.0.[25]

To verify the diagnostic accuracy of HGS in the identification of patients with malnutrition according to SGA, MIS and NRS 2002, ROC (receiver operating characteristic) curves were constructed and areas under the curve (AUC) were obtained. When these values were greater than 0.90, accuracy was considered to be high, while 0.70–0.90 meant moderate accuracy; 0.50–0.69 was considered low and below 0.50, a chance result.[26] Using the same reference standards, the best cutoffs of HGS were obtained for gender, by choosing values that maximize sensitivity and specificity. For these cutoffs, accuracy, positive (PPV) and negative predictive value (NPV) were also calculated.

Based on the HGS values, men and women were classified as nourished (HGS equal to or greater than the cutoff) or malnourished (HGS below the cutoff) to test the association of exposure with nutritional parameters: PA, BMI, %FM, FFM, MAC and MAMC.

The unadjusted and adjusted analysis were performed using the linear regression, where the regression coefficients (β) represent the difference of means of these indicators between the malnourished and the well nourished. The adjusted analysis was performed to avoid overestimating or underestimating the associations by possible confounding factors. For adjustment, the following were included together in the regression model: the main exposure variable (HGS, dichotomic) and the co-variables for which the unadjusted analysis presented $P < 0.20$ in the association with the outcomes (age of patient, history of diabetes mellitus, adequacy and time of HD). All the analyses were stratified by gender. The level of statistical significance was of 5% and for regression, the respective confidence intervals of 95% (CI 95%) were obtained.

3. Results

The study included 85 men (62%) and 53 women (38%), aged from 24 to 84 years (55.4 ± 15.2 years) and HD time ranged from 3 months to 23 years (median 36 months). Almost a third of the patients ($N = 40$, 29%) was older than 65 years. Among the refusals to participate in the study ($N = 25$), there was a greater proportion of women (52%), but this relationship was not different for the participants of the study ($P = 0.20$). The mean age of refusals (53.8 ± 12.2 years) was also similar ($P = 0.62$).

The causes of chronic kidney disease were: hypertension (36.2%), diabetes mellitus (15.9%), glomerulonephritis (13.8%), polycystic kidney disease (8.0%) and other cases or indeterminate reason (26.1%).

Table 1 shows the main clinical characteristics of patients, with results stratified by gender. The mean HGS, weight, height, FFM and MAMC were higher in men than in women, while women showed higher %FM than men ($P < 0.05$). Hypertension was the most prevalent comorbidity, but there was no difference in the prevalence of this disease between men and women, as regards prevalence of diabetes mellitus, heart disease and laboratory parameters. Regarding dialysis dose, men had worse dialysis adequacy than women ($P < 0.001$).

Table 2 shows that in women there was a moderately negative correlation of HGS with SGA, MIS and NRS 2002, and moderately positive with PA. In men, SGA, MIS and NRS 2002 had a weak negative correlation with HGS, whereas the correlation was moderate positive for the PA, FFM, MAC and MAMC.

Fig. 1 shows the ROC curves with the values of diagnostic accuracy of HGS in the identification of men and women with malnutrition according to SGA, MIS and NRS 2002. The figure also shows AUC, where HGS showed moderate accuracy in women and low among men, and AUC was the highest for NRS 2002, in both genders.

Table 3 shows sensitivity, specificity, accuracy, cutoffs, PPV and NPV of the diagnosis of malnutrition of HGS compared with the three reference standards. In women, sensitivity, specificity and accuracy values ranged between 79% and 88%, and these were the best results found when compared with NRS 2002. In turn, PPV (probability of having HGS higher or equal to the cutoff, when well nourished) was higher in all cases than NPV (probability of having a lower HGS than the cutoff, when malnourished). In men, sensitivity, specificity and accuracy were low, except for specificity of HGS in relation to SGA; the other values ranged between 55 and 60%. PPV presented best results for SGA and NRS 2002, while NPV was low in all. The cutoff of HGS for women was <18 kg, a value reported by SGA and MIS. The cutoff of HGS chosen for identifying men with malnutrition was <28.5 kg, as reported by MIS.

The estimated prevalence of malnutrition based on these cutoffs was 47.2% in women and 48.2% in men ($P = 0.935$). By SGA,

Table 1
Clinical characteristics of the patients in hemodialysis, stratified by gender.

	Total[a] ($n = 138$)	Women[a] ($n = 53$)	Men[a] ($n = 85$)
Age (years)	55.36 ± 15.19	54.75 ± 15.01	55.75 ± 15.37
Nutritional parameters			
HGS (kg)	25.8 ± 11.3	18.1 ± 5.8	30.6 ± 11.2*
Weight (kg)	65.5 ± 12.5	60.2 ± 11.1	68.9 ± 12.2*
Height (m)	1.62 ± 0.10	1.55 ± 0.8	1.67 ± 0.08*
PA (°)	6.4 ± 1.3	6.2 ± 1.4	6.6 ± 1.2
BMI (kg/m^2)	24.9 ± 3.8	25.1 ± 3.9	24.7 ± 3.7
FM (%)	26.9 ± 9.0	34.2 ± 6.6	22.4 ± 7.1*
FFM (kg)	47.6 ± 9.6	39.1 ± 5.5	52.9 ± 7.5*
MAC (cm)	27.8 ± 3.8	28.3 ± 4.5	27.5 ± 3.2
MAMC (cm)	23.3 ± 2.8	22.5 ± 3.1	23.9 ± 2.5**
Comorbidities[b]			
Diabetes *mellitus* (%)	41 (29.7)	19 (35.9)	22 (25.9)
Hypertension (%)	113 (81.9)	43 (81.1)	70 (82.4)
Heart disease (%)	41 (29.7)	14 (26.4)	27 (31.8)
Renal function			
Dialysis dose (Kt/V)	1.37 ± 0.22	1.47 ± 0.22	1.31 ± 0.20*
HD time (months)[c]	36 (13; 77)	40 (13; 78)	30 (13; 68)

HGS, handgrip strength; PA, phase angle; BMI, body mass index; FM, fat mass; FFM, fat-free mass; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference; HD, hemodialysis.
*$P < 0.001$; **$P < 0.05$.
[a] Mean and standard deviation.
[b] Absolute and relative frequency for the categorical variables.
[c] Median and interquartile range.

Table 2
Correlation of the handgrip strength (HGS) with anthropometric and nutritional screening tools, stratified by gender.

	HGS			
	Women		Men	
	Correlation	P	Correlation	P
SGA	−0.545	<0.001	−0.263	0.015
MIS	−0.635	<0.001	−0.245	0.024
NRS 2002	−0.661	<0.001	−0.349	0.001
PA (°)	0.570	<0.001	0.335	0.003
BMI (kg/m^2)	−0.049	0.732	0.131	0.234
FM (%)	0.056	0.690	−0.052	0.636
FFM (kg)	0.340	0.013	0.535	<0.001
MAC (cm)	0.239	0.085	0.384	<0.001
MAMC (cm)	0.215	0.123	0.386	<0.001

HGS, handgrip strength; SGA, subjective global assessment; MIS, malnutrition-inflammation score; NRS 2002, nutritional risk screening 2002; PA, phase angle; BMI, body mass index; FM, fat mass; FFM, fat-free mass; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference.

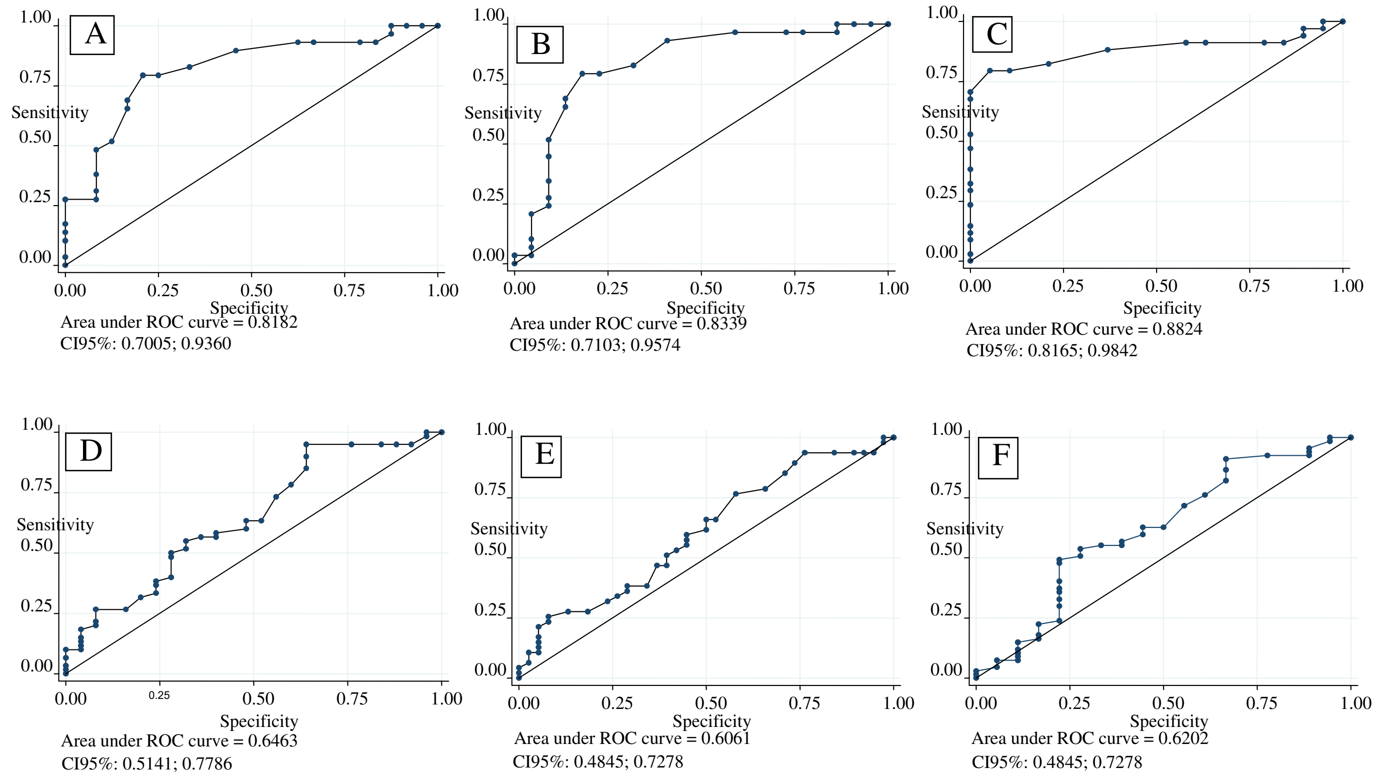

Fig. 1. Receiver operating characteristic (ROC) curves of handgrip strength (HGS) in women with SGA (A), MIS (B), NRS 2002 (C), and of HGS in men with SGA (D), MIS (E) and NRS 2002 (F).

malnutrition was 45.3% for women and 29.4% for men ($P = 0.058$). By MIS, it was 43.1% for women and 42.4% for men ($P = 0.929$). In relation to NRS 2002, women presented 30.2% and men 22.4% ($P = 0.118$).

Table 4 shows the unadjusted and adjusted results of the mean differences of the nutritional parameters among patients classified as malnourished in comparison with the nourished ones according to the cutoff of HGS. Malnourished women had lower values of PA and FFM in the unadjusted analysis. In the adjusted analysis, all nutritional parameters were lower among malnourished women, but these differences showed a value of $P < 0.05$ only for PA, MAC and FFM. Among men, those classified as malnourished had lower values of PA, FFM, MAC and MAMC in the unadjusted analysis. In the adjusted analysis, the mean of all parameters was lower among the malnourished, but these differences were statistically significant only for the FFM, MAC and the MAMC.

Table 3
Diagnostic accuracy of the cutoff of handgrip strength (HGS ≥18 kg in women and ≥28.5 kg in men) when identifying nourished or malnourished patients, compared with the subjective global assessment (SGA), malnutrition-inflammation score (MIS) and nutritional risk screening 2002 (NRS 2002), stratified by gender.

	Sensitivity[a]	Specificity[a]	Accuracy[a]	Cutoff (kg)	Positive predictive value[a]	Negative predictive value[a]
Women						
SGA	79.3	79.2	79.3	18	82.1	76.0
MIS	79.3	81.8	80.4	18	85.2	75.0
NRS 2002	81.1	87.5	83.0	16	96.6	62.5
Men						
SGA	55.0	68.0	58.8	30	80.5	38.6
MIS	59.6	55.3	57.7	28.5	62.2	52.5
NRS 2002	63.6	57.9	62.4	27	83.3	29.7

[a] Value expressed in percentage.

4. Discussion

HGS can be not only a functional and morbimortality parameter, but also a useful tool in assessing nutritional status (reviewed by Norman et al.[10]). However, in hemodialysed patients, it is still poorly documented. Considering the cutoff of HGS for the diagnostic of malnutrition proposed by this study, the results were more accurate in women. However, in men, it was associated with FFM, MAC and MAMC.

In a systematic review about the use of HGS in renal patients, Leal et al.[11] also suggest that this parameter can be used to assess nutritional status, considering changes in muscle mass. Results of studies with hemodialysed patients show that HGS was associated and/or presented high correlation with other techniques of nutritional assessment.[5,6,8]

In the present study, HGS presented negative correlation with all of the nutritional screening tools, and SGA was consistent with a previous study.[5] In turn, both PA and MLG, in both genders, such as FFM and MAC in men, showed a positive correlation with HGS. Similar results were found in other studies in relation to FFM[6,8,27] and MAC,[27] with correlation values also being higher for men.

This result could be related with the greater quantity of muscle mass presented by men, in a way that changes in nutritional status can cause evident changes in muscle strength, due to the impairment of the muscle mass. This finding is consistent with higher values of HGS found in men compared to those found in women, as reported in other studies.[6,12,28]

The association with MAC, MAMC and FFM among men was also detected by comparing the means of these values between well nourished or malnourished patients by cutoffs of HGS. The means of these anthropometric parameters were lower in malnourished patients, even after adjustment. Although HGS was not correlated to the same parameters among women, the mean MAC and FFM

Table 4
Multiple linear regression showing the mean difference of nutritional assessment parameters of malnourished patients compared to nourished patients by handgrip strength (HGS), stratified by gender.

Nutritional parameters	Malnutrition by HGS			
	Women (HGS <18 kg)		Men (HGS <28.5 kg)	
	Unadjusted β (CI95%)[b]	Adjusted[a] β (CI95%)[b]	Unadjusted β (CI95%)[b]	Adjusted[a] β (CI95%)[b]
PA (°)	−1.40 (−2.10; −0.70)*	−1.00 (−1.78; −0.22)**	−0.75 (−1.31; −0.20)**	−0.33 (−0.93; 0.27)
BMI (kg/m^2)	−0.88 (−3.10; 1.32)	−2.00 (−4.29; 0.33)	−0.61 (−2.21; 1.00)	−0.87 (−2.64; 0.91)
%FM (%)	−0.39 (−3.43; 2.64)	−2.99 (−6.11; 0.12)	1.35 (−1.71; 4.41)	−0.46 (−3.75; 2.83)
FFM (kg)	−5.06 (−8.17; −1.95)**	−3.15 (−6.10; −0.20)**	−6.28 (−9.24; −3.33)*	−4.53 (−7.44; −1.62)**
MAC (cm)	−2.29 (−4.72; 0.14)	−2.80 (−5.48; −0.13)**	−2.05 (−3.38; −0.71)**	−1.71 (−3.19; −0.22)**
MACM (cm)	−1.04 (−2.76; 0.68)	−1.30 (−3.19; 0.58)	−1.65 (−2.66; −0.64)**	−1.28 (−2.36; −0.20)**

HGS, handgrip strength; PA, phase angle; BMI, body mass index; %FM, percent fat mass; FFM, fat-free mass; MAC, mid-arm circumference; MAMC, mid-arm muscle circumference.
*$P < 0.001$; **$P < 0.05$.
[a] Adjusted for age, diabetes mellitus, adequacy and duration of HD.
[b] The values of β should be interpreted as the mean difference between malnourished individuals compared to nourished ones according to the cutoff of the HGS for each gender.

values were also lower in the malnourished patients. A similar result was observed in the study by Leal et al.,[6] which reported lower MAMC among patients classified as malnourished by HGS.

A study with hospitalized patients showed that those at nutritional risk, diagnosed by NRS 2002, had lower HGS values.[29] Pieterse, Manandhar and Ismail[28] showed that in elderly patients, HGS is associated with BMI and arm muscle area.

In relation to the cutoff, for the diagnosis of malnutrition, Leal et al.[6] used the 10th percentile of HGS reference values for the Brazilian population.[9] The cutoff of HGS suggested for women in our study (<18 kg) was lower than the one found by Silva et al.[12] (23.4 kg), who evaluated HGS compared with MIS. On the other hand, among men, the diagnostic criteria for malnutrition (<28.5 kg) was more similar to that suggested by Silva et al.[12] (28.3 kg). Several characteristics of our patients, a higher average age and health disease and lower rate of Kt/V, may have accounted for differences from the study conducted by Silva et al.[12]

The suggested cutoff had the MIS as reference standard, since it was specifically developed for renal patients.[1] Furthermore, the entire cutoff showed small numerical variation across the nutritional screening tools used. For this reason, it is suggested that these cutoffs should be used in adult and elderly patients performing HD three times a week. However, they should be used with caution, considering that the tools used as reference, were chosen because there is no gold standard for the diagnosis of malnutrition in hemodialyzed patients.[5]

SGA was used as reference standard in studies evaluating surgical[30,31] and hemodialysed patients.[5] In turn, MIS has been considered as a reference standard to determine the diagnostic accuracy of other parameters[17,32] and HGS.[12] It should be noted that for the classification of malnutrition by MIS, a cutoff of 6.0 was used,[17] but some studies also use a cutoff of 8.0.[4] Results of HGS accuracy with this option of cutoff of MIS show an AUC value of 0.8384 (CI95% 0.7214; 0.9554) in women and 0.7080 (CI95% 0.5578; 0.8583) in men, which was higher the one found by cutoff 6.0, mainly in men. However, the result of the cutoff of HGS was the same, regardless of the classification of malnutrition by MIS (score of 6.0 or 8.0).

In its turn, NRS 2002 is a nutritional screening tool that was developed for hospitalized patients,[18] and it was used as a reference standard to validate HGS.[29] In patients undergoing HD, only one study was found that used this tool, and it was reported that NRS 2002 was a good predictor of hospitalization and mortality.[4]

In our study, the cutoff proposed for HGS had higher specificity than sensitivity in women, and higher sensitivity than specificity in men. PPV was higher than NPV, due to a lower probability of classification error of malnourished patients. This result is of great importance in the clinical area, because the identification of patients that are really malnourished or nourished is essential so that patients with nutritional deficiencies can be treated as soon as possible, thus minimizing clinical complications and reducing mortality.[2,7]

It should be noted that this is the first study that investigated HGS and PA in the same hemodialyzed patients. Regardless of evaluating different compartments of the body, i.e., HGS evaluates muscular strength[10] and PA, the integrity of the cells membranes,[33] both may be related, as PA can predict changes in muscle function.[34] Research with the elderly and patients with cancer showed a moderate positive correlation between PA and HGS,[34,35] suggesting that this may be a predictor of functional capacity.[34]

5. Conclusion

In conclusion, this study showed HGS offers better diagnostic accuracy for the diagnosis of malnutrition in women, taking nutritional screening tools as reference standards. However, HGS showed to be associated with most of the anthropometric nutritional parameters and with PA, in both genders, suggesting that HGS can be a useful nutritional parameter when used as a complement of the nutritional assessment of patients on HD. Further studies are needed to evaluate the prognostic value of HGS in laboratory change detection, clinical complications and mortality among hemodialysis, thus enabling a better understanding of the importance of this parameter in the evaluation of these patients and also for the diagnosis of malnutrition.

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Statement of authorship

MFG made a substantial contribution to the design of the experiment, collection of data, analysis of data, writing of the manuscript and approved the final version of the submitted manuscript. EW made a substantial contribution to the design of the experiment, writing of the manuscript and approved the final version of the manuscript. YMFM and LMF writing of the manuscript, provision of significant advice and approved the final version of the article. DAG made a substantial contribution to analysis of data, writing of the manuscript, provision of significant advice and approved the final version of the submitted manuscript.

Conflict of interest statement

There is no conflict of interest related to the manuscript.

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