Original Article

Handgrip Strength as a Predictor of Nutritional Status in Chinese Elderly Inpatients at Hospital Admission

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Abstract

Objective To assess nutritional status and define gender- and age-specific handgrip strength (HGS) cut-point values for malnutrition or nutritional risk in elderly inpatients.

Methods A cross-sectional study of 1,343 elderly inpatients was conducted in the Chinese PLA General Hospital. Nutrition Risk Screening (NRS 2002) and Subjective Global Assessment (SGA) were administered. Anthropometric measurements and blood biochemical indicators were obtained using standard techniques. The gender- and age-specific receiver operating characteristic (ROC) curves were constructed to evaluate the HGS for nutritional status by SGA and NRS 2002. Sensitivity, specificity, and areas under the curves (AUCs) were calculated.

Results According to NRS 2002 and SGA, 63.81% of elderly inpatients were at nutritional risk and 28.22% were malnourished. Patients with higher HGS had an independently decreased risk of malnutrition and nutritional risk. The AUCs varied between 0.670 and 0.761. According to NRS 2002, the optimal HGS cut-points were 27.5 kg (65-74 years) and 21.0 kg (75-90 years) for men and 17.0 kg (65-74 years) and 14.6 kg (75-90 years) for women. According to SGA, the optimal HGS cut-points were 24.9 kg (65-74 years) and 20.8 kg (75-90 years) for men and 15.2 kg (65-74 years) and 13.5 kg (75-90 years) for women.

Conclusion Elderly inpatients had increased incidence of malnutrition or nutritional risk. HGS cut-points can be used for assessing nutritional status in elderly inpatients at hospital admission in China.

Key words: Handgrip strength; Elderly inpatients; Nutrition assessment; Nutrition status; Malnutrition

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INTRODUCTION

Malnutrition or nutritional risk is often found in elderly inpatients[1-2], primarily due to aging, effects of diseases and drugs, and inadequate dietary intake. Malnutrition or nutritional risk is associated with poor clinical outcomes, longer hospitalizations, a higher likelihood of hospital readmission, higher rates of mortality, and greater hospital expenditures[3-6]. Many nutritional screening or assessment tools are used in hospitals in order to recognize these patients as early as possible, facilitate earlier nutritional intervention, and

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improve health outcomes. The Nutritional Risk Screening (NRS 2002)[7] has been successfully implemented throughout Europe and is recommended for nutritional risk screening of hospitalized patients in China. The Subjective Global Assessment (SGA)[8] is widely used in nutritional assessment and has been recommended as the outcome measure in clinical trials[9-10]. The SGA score can predict health outcomes in elderly hospitalized patients[11]. NRS 2002 is used to identify nutritional risk, whereas SGA detects malnutrition, which is the greatest distinction between the two. They are similar because they both consider the metabolic stress of disease and changes in food intake, although NRS 2002 classifies metabolic stress using numerical scores, whereas SGA depends on the investigator's experience to indicate the metabolic stress of disease[12]. SGA has questions related to the detection of chronic malnutrition; in contrast, NRS 2002 contains questions that indicate a more recent or acute change in nutritional status[13]. These assessment tools are closely related to body weight, particularly, the circumstances surrounding weight that can be determined in an accurate physical assessment conducted by trained staff. It is difficult to carry out such an assessment on every patient, as there are many hospitalized patients in China. Although malnutrition and nutritional risk cannot be assessed using a single parameter, the search is on for an indicator that is a simple and rapid measurement and can increase the accuracy of nutritional evaluation tools.

Patients with malnutrition or nutritional risk have lower hand grip strength (HGS). The potential explanation for this is that malnutrition can reduce protein synthesis, cause muscle fiber atrophy, and reduce muscle mass, further leading to decreased muscle function. Some studies hypothesized that the pathogenesis of impaired muscle function in malnutrition involves reduction of glycolytic enzyme[14-15], creatine[16], and mitochondrial complex activities[17], leading to reductions in muscle glycolysis, phosphocreatine, and oxidative phosphorylation, respectively. Additionally, muscle protein stores have been found to respond rapidly to restoration of nutrition[18]. Together, these mechanisms account for the ability of HGS to predict nutritional status. HGS, a commonly used tool for the assessment of muscle function, has been regarded as an indicator of nutritional status in recent reports[18-19]. HGS can also independently predict nutritional status and changes in nutritional status defined by the Patient-Generated Subjective Global Assessment (PG-SGA) score and category[19]. In addition, HGS may be useful for forecasting prognosis in patients with congestive heart failure[20]. HGS is a rapid, cost-effective nutrition assessment tool; to the best of our knowledge, there is no evaluation standard, and there are no cut-points for malnutrition or nutritional risk in elderly inpatients in China.

The present study aims to assess the nutritional status and the application of HGS in nutrition assessment of elderly inpatients at hospital admission. We anticipate that HGS will show a significant correlation with NRS 2002 and SGA scores and that a combination of the two can be used as an accurate predictor of nutrition status.

METHODS

Participants

The study protocol was reviewed and approved by the Institutional Review Board of Chinese PLA General Hospital. All procedures in this study were conducted in accordance with the Helsinki Declaration, and subjects gave written informed consent.

In this cross-sectional study, a total number of 1,343 patients (691 men and 652 women) between the ages of 65 and 90 years, with a mean age of 73.8 years (SD = 5.9), receiving medical care at internal medicine of Chinese PLA General Hospital were included. Data were obtained by accredited practicing dietitians *via* interviews and clinical screening between May 2014 and December 2015. Briefly, the inclusion criteria were participants who were between 65 and 90 years of age, were admitted for 24 h to the internal medicine wards, and could be measured for handgrip strength. Those who had injury, malformation, or severe rheumatoid arthritis in both hands; pregnant women; and critically ill or unconscious patients were excluded.

Anthropometric and Clinical Data Collection

Body weight and height were recorded to the nearest 0.1 kg and 0.1 cm. Body mass index (BMI) was computed as weight (kg) divided by height (m) squared. Waist circumference (WC) was measured to the nearest 0.1 cm at the umbilical level horizontally in a standing position, and calf circumference (CC) was measured to the nearest 0.1 cm at the thickest point in a relaxed and standing position.

Clinical data including age, gender, hospital department, and diagnosis were collected by nurses at hospital admission. Following admission, fasting blood samples were taken from each patient for laboratory assays including serum levels of albumin (ALB), total protein (TP), creatinine (Cr), triglycerides (TG), total cholesterol (TC), hemoglobin (Hb), blood urea nitrogen, and C-reactive protein (CRP).

Nutrition Status Assessment

Patients' nutrition risk was assessed by using the NRS 2002[7], including initial screening, which consists of four questions as a pre-screening, and final screening, which consists of three aspects: impaired nutritional status, severity of disease, and age. Nutritional assessments were categorized as at nutritional risk (NRS 2002 score ≥ 3) or no nutritional risk (NRS 2002 score < 3).

Nutritional status was determined by using SGA, which was carried out as proposed by Detsky et al.[21]. The following parameters were assessed: body weight change in the previous 6 months and in the last 15 days; nutritional history including appetite, dietary intake, and gastrointestinal symptoms; gastrointestinal derangements including diarrhea, vomiting, and nausea; functional physical capacity; and physical assessment of fat loss, edema, muscle wasting, and ascites. Patients were classified as 'well nourished' (SGA A) or 'malnourished or at risk of malnutrition' (SGA B or C).

HGS Measurement

HGS was measured using a Jamar dynamometer (Sammons Preston, USA) according to a previously described method[22]. The Jamar dynamometer has a range of 1-90 kg and an accuracy of 0.1 kg. The arm was positioned at the side of the body and the dynanometer held with the elbow flexed at 90°. The patient was asked to squeeze the device as hard as possible for 3 s. The measurement was repeated twice more at intervals of at least 30 s. Three measurements were taken from each of the patient's hands. For the present analysis, the maximal value of three consecutive measurements was registered in kilogram units. Then, the mean HGS result was calculated, and the HGS of the dominant hand was recorded. The patient's dominant HGS was used for the assessment.

Statistical Analysis

The data were tabulated using Excel 2007, and statistical analyses for all phases of the study were performed using SPSS 18.0 (SPSS Inc., Chicago IL, USA). Quantitative variables of symmetric and asymmetric distributions were described as the mean ± SD or medians and 25^{th}-75^{th} percentile values, while categorical variables were presented as numbers (proportions).

Frequencies were compared using the χ^2 test. Means and SD values were compared with the Student's *t*-test. The Mann-Whitney *U* test was used to compare asymmetrically distributed quantitative variables. A multivariate logistic regression analysis was used to evaluate significant associations between dominant HGS and other variables while adjusting for potential confounding factors, such as age and disease status. As there are large differences in HGS between genders, the analysis was stratified by gender. Finally, if there was a statistically significant independent association between dominant HGS and nutritional status according to NRS 2002 and SGA, ROC curves were generated to determine the optimal cut-off points for dominant HGS by maximizing Youden's index (sensitivity + specificity − 1)[23]. With the identified cut-off points, the sensitivity, specificity, area under the curve (AUC), and 95% confidence intervals (*CI*s) were calculated. The significance level was set at $P < 0.05$.

RESULTS

Baseline Characteristics of Study Subjects

The characteristics of the 1,343 patients are shown in Table 1. There was no difference in age between men and women. Respiratory (14.59%), endocrinological (15.26%), neurological (22.93%), gastroenterological (11.39%), and cardiological (25.76%) diseases were common at hospital admission. BMI, WC, CC, and HGS; serum levels of TP, Cr, TG, TC, Hb, and CRP; and the number of internal medicine patients were significantly different between women and men.

Nutrition Status Assessment of Study Subjects

The classification of nutritional status by NRS 2002 showed that 63.81% of the population was at nutritional risk (men 69.75%, women 57.52%), while the classification of nutritional status by SGA showed that 28.22% were malnourished (men 25.57%, women 31.13%). Women were at a lower nutritional risk, but at a higher risk of being malnourished (Figure 1).

Comparison of HGS, Anthropometry, and Blood Biochemical Assays as Different Measures of Nutritional Status

The left HGS, right HGS, mean HGS, optimal HGS, BMI, WC, and CC and the serum levels of ALB, TG, and Hb of inpatients with malnutrition or nutritional risk were significantly lower than those of well-nourished inpatients, both male and female. However, in women, age and CRP were higher, and the serum level of TP was significantly lower in malnutrition or nutritional risk inpatients than in well-nourished inpatients (Table 2).

Multiple Logistic Regression Analyses for Malnutrition or Nutrition Risk Stratified by Gender

The multivariate logistic regression model showed that, in male subjects, according to NRS 2002, the odds ratio (*OR*) of optimal HGS was 0.93 (95% *CI* 0.90-0.97, $P < 0.001$), the age *OR* was 1.05 (95% *CI* 1.01-1.10, $P = 0.018$), and the BMI was 0.83 (95% *CI* 0.74-0.92, $P = 0.001$). According to SGA, the

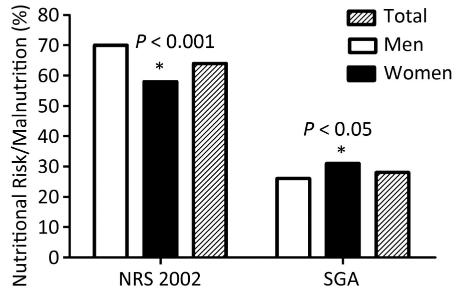

Figure 1. The percentage of nutritional risk or malnutrition in elderly inpatients. Data are presented as proportions (%). Statistically significant differences from the men are indicated as $^{*}P < 0.05$.

Table 1. Baseline Characteristics of Study Subjects

Variables	Men (*n* = 691)	Women (*n* = 652)	Total (*n* = 1,343)	*P* Value
Age (years)	74.0 ± 6.1	73.6 ± 5.6	73.8 ± 5.9	0.286
Body Measurement				
Height (cm)	169.6 ± 5.9	157.5 ± 5.7	163.7 ± 8.3	< 0.001
Weight (kg)	69.2 ± 11.1	61.2 ± 11.6	65.3 ± 12.0	< 0.001
BMI (kg/m^2)	24.1 ± 3.7	24.7 ± 4.4	24.3 ± 4.0	0.007
WC (cm)	91.3 ± 10.9	88.9 ± 11.4	90.1 ± 11.2	< 0.001
CC (cm)	34.5 ± 3.6	33.0 ± 3.7	33.8 ± 3.8	< 0.001
Left HGS (kg)	25.1 ± 8.4	15.4 ± 5.8	20.3 ± 8.8	< 0.001
Right HGS (kg)	26.5 ± 8.7	16.6 ± 6.1	21.7 ± 9.0	< 0.001
Optimal HGS (kg)	26.7 ± 8.6	16.6 ± 6.0	21.8 ± 9.0	< 0.001
Mean HGS (kg)	25.8 ± 8.3	15.9 ± 5.8	21.0 ± 8.7	< 0.001
Blood Biochemical Assays				
ALB (g/L)	38.44 ± 5.12	38.61 ± 5.07	38.52 ± 5.09	0.534
TP (g/L)	64.82 ± 7.23	66.46 ± 7.62	65.64 ± 7.46	< 0.001
BUN (mmol/L)	6.88 ± 5.32	6.67 ± 4.37	6.78 ± 4.88	0.447
Cr (μmol/L)	93.51 ± 55.0	84.81 ± 88.89	89.31 ± 73.42	0.031
TG (mmol/L)	1.29 ± 0.90	1.67 ± 1.88	1.48 ± 1.48	< 0.001
TC (mmol/L)	4.20 ± 2.21	4.73 ± 1.42	4.46 ± 1.89	< 0.001
Hb (g/L)	129.91 ± 21.04	119.52 ± 18.09	124.83 ± 20.32	< 0.001
CRP (mg/dL) - median (P_{25}-P_{75})	2.1 (0.51-11.81)	2.53 (0.54-9.20)	2.3 (0.51-10.7)	0.675
Patients of internal medicine [*n*(%)]				< 0.001
Respiratory	123 (17.80)	73 (11.20)	196 (14.59)	
Endocrinology	90 (13.02)	115 (17.64)	205 (15.26)	
Neurology	183 (26.48)	125 (19.17)	308 (22.93)	
Gastroenterology	78 (11.29)	75 (11.50)	153 (11.39)	
Cardiology	166 (24.03)	180 (27.61)	346 (25.76)	
Nephrology	26 (3.76)	38 (5.83)	64 (4.77)	
Rheumatology	25 (3.62)	46 (7.06)	71 (5.29)	

Note. Data are expressed as mean ± SD or number (percentage) of subjects. Statistical significance of difference is calculated between men and women subjects. BMI: body mass index; HGS: handgrip strength; WC: waist circumference; CC: calf circumference; ALB: albumin; TP: total protein; Cr: creatinine; TG: triglyceride; TC: total cholesterol; Hb: hemoglobin; BUN: blood urea nitrogen; CRP: C-reactive protein.

optimal HGS was 0.93 (95% *CI* 0.89-0.96, $P < 0.001$), the BMI was 0.87 (95% *CI* 0.77-0.99, $P = 0.032$), the ALB was 0.85 (95% *CI* 0.78-0.94, $P = 0.001$), and the TP was 1.07 (95% *CI* 1.01-1.13, $P = 0.017$). For female subjects, according to NRS 2002, the OR of optimal HGS was 0.93 (95% *CI* 0.89-0.98, $P = 0.002$), the age was 0.93 (95% *CI* 0.89-0.98, $P = 0.002$), and the BMI was 0.80 (95% *CI* 0.72-0.88, $P < 0.001$). According to SGA, the *OR* of optimal HGS was 0.93 (95% *CI* 0.88-0.98, $P = 0.003$), the BMI was 0.84 (95% *CI* 0.76-0.94, $P = 0.001$), and the CC *OR* was 0.90 (95% *CI* 0.82-0.99, $P = 0.031$). There was no significant difference in any other variable (Table 3).

The Gender- and Age- specific Optimal HGS Cut-off Points for Nutritional Risk or Malnutrition Screening

To determine the optimal HGS value to detect nutritional risk and malnutrition in men and women, we calculated the optimal HGS cut-off values by maximizing the Youden Index by sex and age (Table 4 and Figure 2). Based on the ROC curve of NRS 2002, we identified the optimal cut-off points as 27.5 kg (65-74 years) and 21.0 kg (75-90 years) for men and 17.0 kg (65-74 years) and 14.6 kg (75-90 years) for women. Likewise, for SGA, we determined the optimal cut-off points as 24.9 kg (65-74 years) and

Table 2. The Comparison HGS, Anthropometry and Blood Biochemical Assays of Different Nutrition Status of Study Subjects

Parameters		NRS 2002			SGA		
		≥ 3	< 3	*P* Value	B or C	A	*P* Value
Men	Left HGS (kg)	21.5 ± 8.3*	27.5 ± 7.6	< 0.001	20.1 ± 7.8*	26.7 ± 8.0	< 0.001
	Right HGS (kg)	22.6 ± 8.4*	29.1 ± 7.9	< 0.001	21.5 ± 8.3*	28.7 ± 7.9	< 0.001
	Mean HGS (kg)	22.0 ± 7.9*	28.3 ± 7.5	< 0.001	20.6 ± 7.7*	27.6 ± 7.7	< 0.001
	Optimal HGS (kg)	22.8 ± 8.2*	29.3 ± 7.9	< 0.001	21.1 ± 7.8*	28.4 ± 8.1	< 0.001
	Age (year)	75.9 ± 5.6*	72.7 ± 6.0	< 0.001	75.6 ± 6.4*	73.4 ± 5.9	< 0.001
	BMI (kg/m^2)	22.4 ± 4.0*	25.1 ± 3.0	< 0.001	21.9 ± 3.7*	24.8 ± 3.3	< 0.001
	WC (cm)	87.3 ± 11.7*	93.9 ± 9.5	< 0.001	86.1 ± 11.2*	93.1 ± 10.2	< 0.001
	CC (cm)	33.3 ± 3.8*	35.4 ± 3.2	< 0.001	32.4 ± 3.7*	35.3 ± 3.3	< 0.001
	ALB (g/L)	37.2 ± 4.9*	39.2 ± 5.1	< 0.001	36.2 ± 5.4*	39.2 ± 4.8	< 0.001
	TP (g/L)	64.3 ± 7.6	65.2 ± 7.0	0.105	64.1 ± 8.1	65.1 ± 6.9	0.128
	TG (mmol/L)	1.09 ± 0.59*	1.42 ± 1.04	< 0.001	1.07 ± 0.56*	1.36 ± 0.98	< 0.001
	TC (mmol/L)	4.02 ± 1.04	4.32 ± 2.70	0.094	3.99 ± 1.15	4.27 ± 2.46	0.161
	HB (g/L)	125.7 ± 23.2*	132.5 ± 19.1	< 0.001	122.1 ± 23.7*	132.5 ± 19.4	< 0.001
	CRP (mg/dL) - median (P_{25}-P_{75})	2.57 (0.34-21.76)	2.06 (0.56-9.00)	0.514	1.72 (0.67-40.51)	2.10 (0.40-9.94)	0.072
Women	Left HGS (kg)	13.1 ± 5.5*	16.9 ± 5.5	< 0.001	12.9 ± 5.4*	16.5 ± 5.6	< 0.001
	Right HGS (kg)	14.0 ± 5.5*	18.3 ± 5.8	< 0.001	13.6 ± 5.6*	17.9 ± 5.8	< 0.001
	Mean HGS (kg)	13.5 ± 5.4*	17.5 ± 5.5	< 0.001	13.2 ± 5.6*	17.2 ± 5.5	< 0.001
	Optimal HGS (kg)	14.1 ± 5.6*	18.3 ± 5.7	< 0.001	13.6 ± 5.6*	18.0 ± 5.7	< 0.001
	Age (year)	75.5 ± 5.5*	72.3 ± 5.4	< 0.001	75.0 ± 6.0*	73.0 ± 5.4	< 0.001
	BMI (kg/m^2)	22.7 ± 4.5*	26.0 ± 3.9	< 0.001	22.4 ± 4.4*	25.7 ± 4.0	< 0.001
	WC (cm)	86.0 ± 12.1*	90.8 ± 10.4	< 0.001	84.9 ± 11.7*	90.6 ± 10.7	< 0.001
	CC (cm)	31.6 ± 3.9*	33.9 ± 3.4	< 0.001	31.1 ± 3.9*	33.8 ± 3.3	< 0.001
	ALB (g/L)	37.5 ± 5.3*	39.4 ± 4.7	< 0.001	37.3 ± 5.4*	39.2 ± 4.8	< 0.001
	TP (g/L)	65.4 ± 7.9*	67.2 ± 7.3	0.003	64.8 ± 8.4*	67.2 ± 7.1	0.002
	TG (mmol/L)	1.48 ± 1.38*	1.80 ± 2.14	0.039	1.42 ± 0.87*	1.78 ± 2.17	0.028
	TC (mmol/L)	4.74 ± 1.76	4.73 ± 1.15	0.976	4.73 ± 1.94	4.74 ± 1.13	0.949
	HB (g/L)	117.0 ± 19.7*	121.1 ± 16.8	0.005	115.7 ± 20.5*	121.2 ± 16.7	0.001
	CRP (mg/dL) - median (P_{25}-P_{75})	3.24 (0.60-13.45)*	1.90 (0.46-7.45)	0.039	3.70 (0.77-13.20)*	2.84 (0.55-8.31)	0.043

Note. Statistical significance of difference is calculated between different nutrition status, $^*P < 0.05$.

Table 3. Multivariate Logistic Regression Analyses for Malnutrition or Nutrition Risk Stratified by Gender

Variable		NRS 2002			SGA		
		Standardized *β*	*OR* (95% *CI*)	*P* Value	Standardized *β*	*OR* (95% *CI*)	*P* Value
Men	Optimal HGS	-0.07	0.93 (0.90-0.97)	< 0.001	-0.08	0.93 (0.89-0.96)	< 0.001
	Age	0.05	1.05 (1.01-1.10)	0.018	0.01	1.01 (0.96-1.06)	0.827
	BMI	-0.19	0.83 (0.74-0.92)	0.001	-0.14	0.87 (0.77-0.99)	0.032
	WC	-0.02	0.98 (0.94-1.01)	0.198	-0.01	0.99 (0.96-1.04)	0.786
	CC	0.02	1.02 (0.92-1.12)	0.756	-0.10	0.90 (0.81-1.01)	0.086
	ALB	0.06	0.94 (0.87-1.02)	0.162	-0.16	0.85 (0.78-0.94)	0.001
	TP	0.01	1.01 (0.96-1.06)	0.608	0.07	1.07 (1.01-1.13)	0.017
	TC	-0.13	0.88 (0.68-1.13)	0.311	-0.18	0.84 (0.63-1.12)	0.236
	Hb	0.01	1.01 (0.99-1.03)	0.116	0.01	1.01 (0.99-1.03)	0.314
	CRP	0.01	1.01 (1.00-1.01)	0.190	0.01	1.01 (1.00-1.03)	0.140
Women	Optimal HGS	-0.07	0.93 (0.89-0.98)	0.003	-0.07	0.93 (0.88-0.98)	0.003
	Age	0.07	0.93 (0.89-0.98)	0.002	0.03	0.93 (0.88-0.98)	0.157
	BMI	-0.23	0.80 (0.72-0.88)	< 0.001	-0.17	0.84 (0.76-0.94)	0.001
	WC	0.01	1.01 (0.98-1.04)	0.452	0.01	1.01 (0.98-1.05)	0.415
	CC	0.03	0.97 (0.89-1.06)	0.505	-0.10	0.90 (0.82-0.99)	0.031
	ALB	-0.05	0.96 (0.89-1.03)	0.221	0.05	0.96 (0.89-1.04)	0.286
	TP	-0.01	0.99 (0.95-1.04)	0.743	-0.02	0.98 (0.94-1.03)	0.393
	TC	0.02	1.03 (0.86-1.23)	0.792	0.05	1.07 (0.89-1.30)	0.476
	Hb	0.01	1.01 (0.99-1.02)	0.238	0.00	1.00 (0.99-1.01)	0.902
	CRP	0.00	1.00 (0.99-1.01)	0.451	0.00	1.00 (0.99-1.01)	0.771

Note. *β*: regression coefficient; *OR*: odds ratios; *CI*: confidence interval.

Table 4. Gender- and Age- Specific ROC Curve of the Optimal HGS to Screen Malnutrition or Nutritional Risk on the Basis of SGA and NRS 2002 in Elderly Inpatients

Variable		Age (year)	AUC	*SE*	*P*	95% *CI*	Cut-point (kg)	Sensitivity (%)	Specificity (%)	Nutritional Risk/Malnutrition, *n* (%)
Men	NRS	65-74	0.734	0.027	< 0.001	0.678-0.786	27.5	69.1	63.6	155 (41.11)
	2002	75-90	0.670	0.030	< 0.001	0.611-0.729	21.0	83.3	44.8	97 (30.89)
	SGA	65-74	0.761	0.029	< 0.001	0.703-0.819	24.9	78.0	58.5	113 (29.97)
		75-90	0.715	0.032	< 0.001	0.653-0.777	20.8	81.8	54.3	91 (28.98)
Women	NRS	65-74	0.688	0.029	< 0.001	0.630-0.746	17.0	70.5	58.6	145 (38.46)
	2002	75-90	0.687	0.032	< 0.001	0.624-0.750	14.6	69.3	62.8	132 (48.00)
	SGA	65-74	0.672	0.033	< 0.001	0.608-0.736	15.2	77.4	53.2	114 (30.24)
		75-90	0.720	0.031	< 0.001	0.660-0.781	13.5	71.7	65.1	140 (50.91)

Note. AUC: area under the curve; *SE*: standard error; *CI*: confidence interval.

20.8 kg (75-90 years) for men and 15.2 kg (65-74 years) and 13.5 kg (75-90 years) for women.

DISCUSSION

Our study found a strong correlation between HGS and nutritional status in elderly inpatients at hospital admission, in agreement with previous literature[18-19,24-26]. Our findings also demonstrated that HGS cut-off values can identify a high proportion of elderly inpatients with malnutrition or at nutritional risk and can be used for assessing the nutritional status of elderly inpatients at hospital admission in China.

The prevalence of malnutrition or nutritional risk was greater than 40% among elderly inpatients[1-2,27]. This study showed a 64% prevalence of nutritional risk and a 28% prevalence of malnourishment in elderly inpatients at hospital admission, and the prevalence of nutritional risk and HGS was lower and that of malnourishment was higher in women than in men. Age and sex were the two most important independent determining factors of HGS[28-29]. HGS decreases with increasing age[30-31], and the rate of loss of HGS was shown to be twice as fast in older groups compared with that in younger groups. Moreover, older women had 43% lower HGS than older men[30,32]. This study involved elderly inpatients who were assessed by SGA or NRS 2002 to identify malnutrition or nutritional risk. We found that HGS, BMI, WC, and CC and the serum level of ALB, TG, and Hb of inpatients with malnutrition or nutritional risk were significantly lower, and the age was higher than that of well-nourished inpatients, both male and female. However, in women serum levels of TP were significantly lower, and those of CRP were significantly higher. This showed that HGS, like other indicators, was a stronger predictor of nutritional status. We further analyzed the adjusted multivariate logistic regression model and showed that lower HGS was associated with malnutrition or nutritional risk status in patients of both sexes. Similar to other studies, HGS and PG-SGA scores were significantly correlated[19], as was impaired handgrip strength with poor nutritional status (BMI < 18.5 kg/m^2)[26]. A systematic review highlighted HGS as

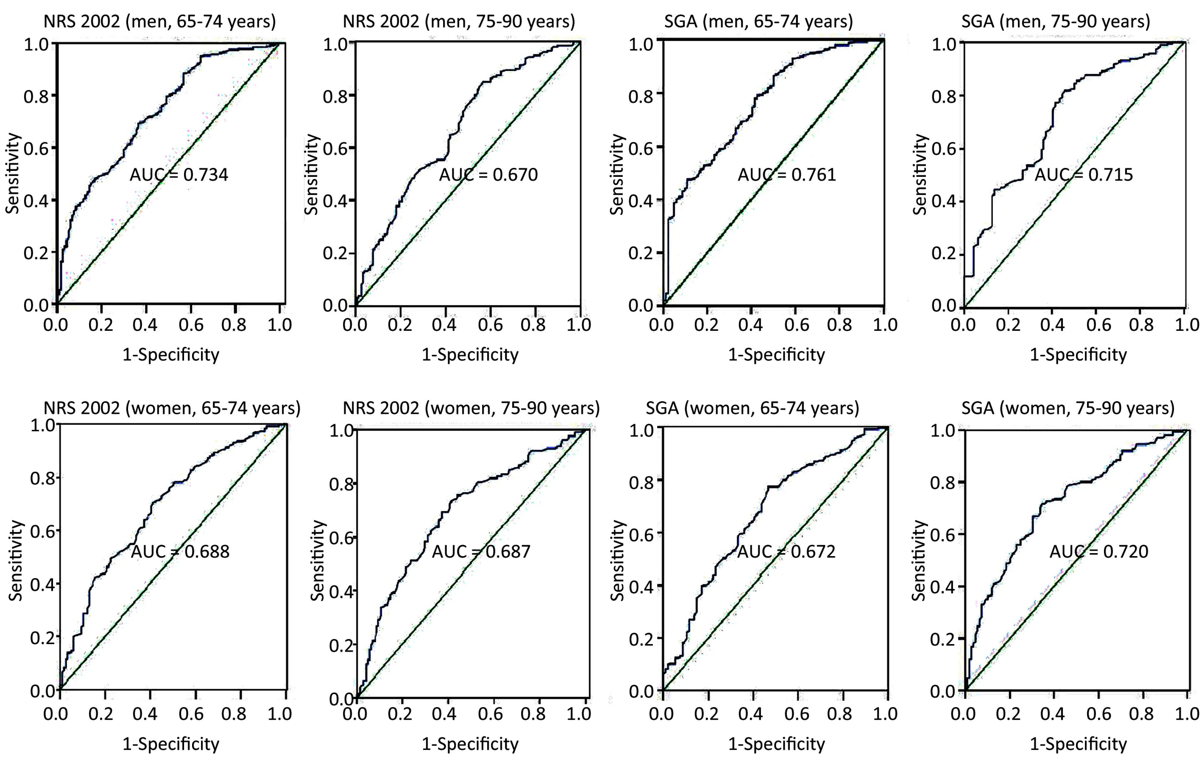

Figure 2. Gender- and age- specific ROC curves for identifying malnutrition or nutrition risk according to different cut-points for optimal HGS. AUC is indicated in the figure. The AUC is significantly different from 0.5, *P* < 0.05 for all.

a good indicator of nutrition status[18], and HGS is an excellent tool to assess nutrition status at the bedside in patients with cirrhosis. Furthermore, HGS has higher diagnostic accuracy than other anthropometric tests such as mid-arm muscle circumference and triceps skin fold thickness[33].

HGS reflects overall body muscle strength and can indicate nutritional deprivation before a change occurs in body composition[18,34]. HGS can be a reliable first screening tool for nutritional risk in hospitals[35] and can independently predict nutritional status and changes in nutritional status defined by PG-SGA score and category[19]. A study reported that the overall HGS cut-points for the likelihood of mobility limitation were 37 kg for men and 21 kg for women[36]. Another study reported that only men with low handgrip strength had an increased risk of functional decline at discharge, with a specificity of 91.3% and a cut-off point of 20.65 kg for handgrip strength, whereas women had no significant association between handgrip strength and functional decline[37]. This study reported that the HGS cut-points for the likelihood of nutritional risk were 27.5 kg (65-74 years) and 21.0 kg (75-90 years) for men and 17.0 kg (65-74 years) and 14.6 kg (75-90 years) for women, and the HGS cut-points for the likelihood of malnutrition were 24.9 kg (65-74 years) and 20.8 kg (75-90 years) for men and 15.2 kg (65-74 years) and 13.5 kg (75-90 years) for women. Guerra et al.[23] reported that the cut-off value for men older than 65 years was 30.2 kg when screening undernourished patients classified by PG-SGA. The risk of poor nutrition might be a predictor of lower physical performance. The HGS cut-off value for physical performance was 16.2 kg in elderly female cardiac inpatients[38] and 22.7 kg in elderly post-cardiac surgery patients complicated by diabetes mellitus[39].

There was a high prevalence of malnutrition in cirrhotic outpatients, especially when assessed by HGS, which was superior to SGA and the prognostic nutritional index (PNI)[40]. As stated earlier, elderly inpatients also had a high prevalence of malnutrition or nutritional risk; according to the HGS cut-points, the prevalence of nutritional risk and malnutrition was, respectively, 51.1% and 27.5% for men and 51.2% and 41.4% for women. HGS identified a high proportion of inpatients at nutritional risk, indicating that it was a reliable first screening tool for nutritional risk in elderly inpatients.

Our analysis was based on a large sample size (*n* = 1,343) and included male and female inpatients aged more than 65 years from a variety of wards. There are also some limitations to this study. First, there is no consensus on the assessment protocol for HGS[18]. This limits the comparison between our study and others that used different methodologies. Second, there is no gold standard for evaluating elderly patients' nutritional status. Our study was based on the SGA and NRS 2002, which can assess malnutrition and screen for nutritional risk, respectively. Third, the lack of HGS data on elderly patients in China also limited comparisons of our study with others. Fourth, the HGS is a simple parameter, which provides valuable information in addition to the assessment of nutritional status. Finally, the study could not clarify the cause-effect association between HGS and malnutrition or nutritional risk, as this was a cross-sectional analysis. Reliable HGS cut-off values remain to be proposed and validated.

In conclusion, elderly inpatients were associated with a greater incidence of malnutrition or nutritional risk. Our research demonstrates that HGS can independently predict nutrition status, as assessed by SGA and screened by NRS 2002. HGS cut-off values for nutritional risk screening at hospital admission were 27.5 kg (65-74 years) and 21.0 kg (75-90 years) for men and 17.0 kg (65-74 years) and 14.6 kg (75-90 years) for women, and the HGS cut-off values for malnutrition assessment were 24.9 kg (65-74 years) and 20.8 kg (75-90 years) for men and 15.2 kg (65-74 years) and 13.5 kg (75-90 years) for women. These HGS cut-off values should be tested in other samples and validated in future studies.

CONFLICT OF INTEREST

No conflict of interest to declare.

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REFERENCES

1. Araujo Dos Santos C, De Oliveira Barbosa Rosa C, Queiroz Ribeiro A, et al. Patient-Generated Subjective Global Assessment and Classic Anthropometry: Comparison between the Methods in Detection of Malnutrition among Elderly with Cancer. Nutr Hosp, 2015; 31, 384-92.

2. Sanz Paris A, Garcia JM, Gomez-Candela C, et al. Malnutrition prevalence in hospitalized elderly diabetic patients. Nutr Hosp, 2013; 28, 592-9.
3. Klek S. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality--letter to the editor. Clin Nutr, 2013; 32, 488.
4. Sorensen J, Kondrup J, Prokopowicz J, et al. EuroOOPS: an international, multicentre study to implement nutritional risk screening and evaluate clinical outcome. Clin Nutr, 2008; 27, 340-9.
5. Wells JL, Dumbrell AC. Nutrition and aging: assessment and treatment of compromised nutritional status in frail elderly patients. Clin Interv Aging, 2006; 1, 67-79.
6. Keevil V, Mazzuin Razali R, Chin AV, et al. Grip strength in a cohort of older medical inpatients in Malaysia: a pilot study to describe the range, determinants and association with length of hospital stay. Arch Gerontol Geriatr, 2013; 56, 155-9.
7. J K, HH R, O H, et al. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. Clin Nutr, 2003; 22, 321-36.
8. Detsky AS, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? JPEN-Parenter Enteral, 1987; 11, 8-13.
9. Salva A, Corman B, Andrieu S, et al. Minimum data set for nutritional intervention studies in elderly people. J Gerontol A-Biol, 2004; 59, 724-9.
10. Fontes D, Generoso SD, Toulson Davisson Correia MI. Subjective global assessment: A reliable nutritional assessment tool to predict outcomes in critically ill patients. Clin Nutr, 2014; 33, 291-5.
11. Van Nes MC, Herrmann FR, Gold G, et al. Does the mini nutritional assessment predict hospitalization outcomes in older people? Age Ageing, 2001; 30, 221-6.
12. Kondrup J, Allison SP, Elia M, et al. Educational and Clinical Practice Committee, European Society for Clinical Nutrition and Metabolism (ESPEN). ESPEN guidelines for nutrition screening 2002. Clin Nutr, 2003; 22, 415e21.
13. Raslan M1, Gonzalez MC, Torrinhas RS, et al. Complementarity of Subjective Global Assessment (SGA) and Nutritional Risk Screening 2002 (NRS 2002) for predicting poor clinical outcomes in hospitalized patients. Clin Nutr, 2011; 30, 49-53.
14. Russell DM, Walker PM, Leiter LA, et al. Metabolic and structural changes in skeletal muscle during hypocaloric dieting. Am J Clin Nutr, 1984; 39, 503-13.
15. Ardawi MS, Majzoub MF, Masoud IM, et al. Enzymic and metabolic adaptations in the gastrocnemius, plantaris and soleus muscles of hypocaloric rats. Biochem J, 1989; 261, 219-25.
16. Thompson A, Damyanovich A, Madapallimattam A, et al. 31P-nuclear magnetic resonance studies of bioenergetic changes in skeletal muscle in malnourished human adults. Am J Clin Nutr, 1998; 67, 39-43.
17. Madapallimattam AG, Law L, Jeejeebhoy KN. Effect of hypoenergetic feeding on muscle oxidative phosphorylation and mitochondrial complex I-IV activities in rats. Am J Clin Nutr, 2002; 76, 1031-9.
18. Norman K, Stobaus N, Gonzalez MC, et al. Hand grip strength: outcome predictor and marker of nutritional status. Clin Nutr, 2011; 30, 135-42.
19. Flood A, Chung A, Parker H, et al. The use of hand grip strength as a predictor of nutrition status in hospital patients. Clin Nutr, 2014; 33, 106-14.
20. Izawa KP, Watanabe S, Osada N, et al. Handgrip strength as a predictor of prognosis in Japanese patients with congestive heart failure. Eur J Cardiovasc Prev Rehabil, 2009; 16, 21-7.
21. AS D, JR M, JP B, et al. What is subjective global assessment of nutritional status? JPEN-Parenter Enteral, 1987; 11, 8-13.
22. Leong DP, Teo KK, Rangarajan S, et al. Reference ranges of handgrip strength from 125,462 healthy adults in 21 countries: a prospective urban rural epidemiologic (PURE) study. J Cachexia Sarcopenia Muscle, 2016; 7, 535-46.
23. Guerra RS, Fonseca I, Pichel F, et al. Handgrip strength cutoff values for undernutrition screening at hospital admission. Eur J Clin Nutr, 2014; 68, 1315-21.
24. Silva C, Amaral TF, Silva D, et al. Handgrip strength and nutrition status in hospitalized pediatric patients. Nutr Clin Pract, 2014; 29, 380-5.
25. Flood A, Chung A, Parker H, et al. The use of hand grip strength as a predictor of nutrition status in hospital patients. Clin Nutr, 2014; 33, 106-14.
26. Pieterse S, Manandhar M, Ismail S. The association between nutritional status and handgrip strength in older Rwandan refugees. Eur J Clin Nutr, 2002; 56, 933-9.
27. de Luis DA, Lopez Mongil R, Gonzalez Sagrado M, et al. Evaluation of the mini-nutritional assessment short-form (MNA-SF) among institutionalized older patients in Spain. Nutr Hosp, 2011; 26, 1350-4.
28. Puh U. Age-related and sex-related differences in hand and pinch grip strength in adults. Int J Rehabil Res, 2010; 33, 4-11.
29. van Lier AM, Payette H. Determinants of handgrip strength in free-living elderly at risk of malnutrition. Disabil Rehabil, 2003; 25, 1181-6.
30. Ranganathan VK, Siemionow V, Sahgal V, et al. Effects of aging on hand function. J Am Geriatr Soc, 2001; 49, 1478-84.
31. Chilima DM, Ismail SJ. Nutrition and handgrip strength of older adults in rural Malawi. Public Health Nutr, 2001; 4, 11-7.
32. Bassey EJ. Longitudinal changes in selected physical capabilities: muscle strength, flexibility and body size. Age Ageing, 1998; 27 Suppl 3, 12-6.
33. Sharma P, Rauf A, Matin A, et al. Handgrip Strength as an Important Bed Side Tool to Assess Malnutrition in Patient with Liver Disease. J Clin Exp Hepatol, 2017; 7, 16-22.
34. Rantanen T, Volpato S, Ferrucci L, et al. Handgrip strength and cause-specific and total mortality in older disabled women: exploring the mechanism. J Am Geriatr Soc, 2003; 51, 636-41.
35. Matos LC, Tavares MM, Amaral TF. Handgrip strength as a hospital admission nutritional risk screening method. Eur J Clin Nutr, 2007; 61, 1128-35.
36. Sallinen J, Stenholm S, Rantanen T, et al. Hand-grip strength cut points to screen older persons at risk for mobility limitation. J Am Geriatr Soc, 2010; 58, 1721-6.
37. Garcia-Pena C, Garcia-Fabela LC, Gutierrez-Robledo LM, et al. Handgrip strength predicts functional decline at discharge in hospitalized male elderly: a hospital cohort study. PloS One, 2013; 8, e69849.
38. Izawa KP, Watanabe S, Oka K, et al. Differences in physical performance based on the Geriatric Nutritional Risk Index in elderly female cardiac patients. Aging Clin Exp Res, 2015; 27, 195-200.
39. Izawa KP, Watanabe S. Relation of nutritional status to physiological outcomes after cardiac surgery in elderly patients with diabetes mellitus: a preliminary study. Aging Clin Exp Res, 2016; 28, 1267-71.
40. Alvares-da-Silva MR, Reverbel da Silveira T. Comparison between handgrip strength, subjective global assessment, and prognostic nutritional index in assessing malnutrition and predicting clinical outcome in cirrhotic outpatients. Nutrition, 2005; 21, 113-7.