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Research Article
Validation of Handgrip Strength as a Nutritional Assessment Tool for Hemodialysis Patients in Dr. Sardjito Hospital, Indonesia

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Abstract

Background and Objective: Handgrip strength (HGS) is used for continuous and systematic assessment of muscle mass related to nutritional status in hemodialysis (HD) patients. This study aimed to evaluate the ability of the HGS test to assess the nutritional status of hemodialysis patients. **Materials and Methods:** Data were collected from 104 patients with chronic kidney disease (CKD) undergoing routine HD in Dr. Sardjito Hospital, Yogyakarta, Indonesia. Patients were selected for the study using purposive sampling. All subjects were assessed using the HGS test and then compared using the subjective global assessment (SGA), dialysis malnutrition score (DMS), nutritional risk screening 2002 (NRS 2002) and simple nutrition screening tool (SNST). Correlation tests were conducted to determine associations between HGS and SGA, DMS, NRS 2002, SNST, body mass index and mid-upper arm circumference (MUAC). **Results:** The sensitivity of HGS for the study of male participants was the highest when compared to SGA (76.9%), but it had low specificity, accuracy, positive predictive value and area under the curve. HGS performed poorly when compared to other tools. For women in the study, HGS had highest specificity when compared to SGA (79.2%), but it had low sensitivity, positive and negative predictive values and area under the curve. When compared to other tools, HGS gave an even lower result. HGS had a negative correlation with the other four nutritional assessment tools, but it had a positive correlation with MUAC. **Conclusion:** The HGS test appeared to be an inaccurate assessment of nutritional status in male and female CKD patients undergoing hemodialysis.

Key words: Handgrip strength, nutritional assessment, hemodialysis, malnutrition, chronic kidney disease (CKD)

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Malnutrition is one of many problems occurring in chronic kidney disease (CKD) patients on hemodialysis. The prevalence of malnutrition in hemodialysis (HD) patients is high, ranging from 23-73%[1]. Because malnutrition causes physiological dysfunction that affects the patient's quality of life, nutritional assessment of CKD patients on hemodialysis is necessary.

The handgrip strength (HGS) test is simple, easily performed, quick and inexpensive[2]. A systematic review and meta-analysis indicated that HGS is a useful tool for continuously and systematically assessing muscle mass related to nutritional status in patients on dialysis[3]. Many studies evaluate HGS as a predictor of malnutrition in hemodialysis patients. However, there have been no validity tests to determine the efficacy of the HGS method in predicting malnutrition in hemodialysis patients.

This study evaluated the ability of the HGS test to assess nutritional status in CKD patients on hemodialysis based on the subjective global assessment (SGA), dialysis malnutrition score (DMS), nutritional risk screening 2002 (NRS 2002) and simple nutritional screening tool (SNST). This study also determined the correlations between handgrip strength and body mass index (BMI) and mid-upper arm circumference (MUAC).

MATERIALS AND METHODS

Subject and nutritional assessment: This was an observational study with a cross-sectional design. The study population included CKD patients on hemodialysis at Dr. Sardjito hospital, Yogyakarta, Indonesia selected using purposive sampling. Patients met the following inclusion criteria: Over 19 years of age, undergoing hemodialysis for at least 3 months (a minimum of twice a week), able to communicate well and willing to be a subject in this study and sign an informed consent. Exclusion criteria were pregnancy, hospital admission for any reason during the evaluation and atrophied upper limb. Of the 104 patients eligible for this study, 59 were men and 45 were women. The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Gadjah Mada University. Informed consent was obtained from all patients at the time of study enrollment.

The handgrip strength test measures the upper extremity muscle's function. A camry handgrip dynamometer with 0.01 kg accuracy was used to measure study patients' handgrip strength. Handgrip strength was measured on the non-fistula arm throughout the hemodialysis process. Subjects were instructed to self-adjust the dynamometer so that it fit comfortably to their hand size to obtain the best performance. The subjects lie down with both arms extended sideways from the body with the dynamometer facing away from the body and then they were instructed to grip the dynamometer with maximum strength for 10 sec. A minute-long rest time was granted between each measurement and an average value was calculated. Low handgrip strength in patients indicates malnutrition. Low handgrip strength cutoffs, as determined by Wang *et al.*[2], are HGS $\leq$20 for men and HGS $\leq$10 for women[2].

SGA is a nutritional status instrument recommended by the National Kidney Foundation (NKF)[4]. Study patients were divided into three categories using SGA. Patients were classified category A if well nourished, category B if moderately (or suspected of being) malnourished, or category C if severely malnourished[5]. B and C category patients were included in the malnutrition category for statistical analysis. DMS is an advanced form of conventional SGA[6]. Patients with DMS scores of 7-13 were categorized as well-nourished, scores of 14-23 were mildly to moderately malnourished and scores of 24-35 were severely malnourished[7]. For the purpose of statistical analysis, patients were categorized as malnourished if their DMS score was 14-35. NRS 2002 classified patients as not at risk for malnutrition (<3) or at risk for malnutrition (>3)[8]. SNST is a new nutritional screening tool developed by Susetyowati, which interprets results to be at no risk of malnutrition (<3) or at risk of malnutrition ($\geq$3)[9].

The patients' height (m), weight (kg), MUAC (cm) and BMI (kg m^{-2}) were measured. Measurements were taken by trained enumerators using standard procedures.

Height body was measured using microtoa with 0.1 cm accuracy. Subjects stood with their scapula, buttocks and heels resting against a wall. The neck was held in a natural non stretched position, the heels were touching each other, the toe tips formed a 45°C angle and the head was held straight with the inferior orbital border in the same horizontal plane as the external auditive conduct. Weight body was measured using camry digital weighing scale with 200 kg maximum capacity and 100 g error margin. Subjects stands with minimal movement with hands by their side. They should remove shoes and heavy cloths prior to weighing[10]. MUAC was calculated by measuring the circumference of the upper arm at the midpoint between the tip of the shoulder (acromion) and the tip of the elbow (olecranon process) using met-line. Measurements were taken twice and the average result was calculated. The significance of the statistical analysis was 5% ($p<0.05$) or confidence interval (CI) was 95%.

Statistical analysis: IBM statistics 22 software was used to analyze the data. The software used has an online lisence from Universitas Gadjah Mada, Yogyakarta, Indonesia. The sample descriptions are presented as absolute values and percentages, average scores and standard deviations, or median and quartile ranges of the evaluated variables. Student's t-tests, Mann-Whitney tests and chi-squared tests were used to determine average differences in the male and female groups. Sensitivity (Sn), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) assessed the accuracy of the HGS method, using SGA, DMS, NRS 2002 and SNST as standard references and were analyzed using 2x2 table (crosstab) analysis. Receiver operating characteristic (ROC) curve analysis was used to acquire the HGS method's area under the curve (AUC) value. Pearson's correlation was used to determine the correlation between two variables.

RESULTS

The study included 104 patients, consisting of 59 men (56.7%) and 45 women (43.3%), aged from 21-81 years old (51.35±12.67). HD time ranged from 3 months to 19 years (median 29 months). Men's height, weight and handgrip strength measurements were higher on average than women's measurements ($p \leq 0{,}001$). MUAC and BMI measurements were also higher among men but not significantly. Hypertension was the most frequent comorbidity among both men and women (Table 1).

SNST was able to detect the most malnutrition cases in both the male group (52.5%) and female group (64.4%) compared to the other four standard reference nutritional screening tools. The HGS test was able to detect malnutrition in 44.2% of patients (Table 2).

Table 3 shows the sensitivity, specificity, PPV, NPV and accuracy of the HGS method compared to the reference standards SGA, DMS, NRS 2002 and SNST. Sensitivity, specificity and accuracy values for men ranged from 56-77%. All validity test results (sensitivity, specificity, PPV and NPV) were included in the low category (<70%), except for sensitivity and NPV of SGA and DMS. NPV represents the probability of true negative malnutrition and PPV represents the probability of true positive malnutrition[11]. The area under the curve (AUC) values of all tests were low, <0.70[12]. All validity test results in the women's group were also included in the low category except specificity for SGA (79.2%) and DMS (76.2%).

Among male patients, there were negative correlations with a medium correlation coefficient between HGS and SGA, DMS, NRS 2002 and SNST, while there was a positive correlation with MUAC. Meanwhile, there are insignificant negative correlations with a low correlation coefficient between all parameters and HGS among female patients (Table 4).

Table 1: Clinical characteristic of patients in hemodialysis, stratified by gender

Variables	Total[a] (N = 104)	Men[a] (N = 59)	Women[a] (N = 45)	P[d]
Age (years)	51.35±12.67	50.86±14.68	51.98±9.55	0.659
Nutritional parameters				
HGS (kg)	17.3±9.3	21.0±9.9	12.5±5.7	<0.001
Height (m)	1.59±0.08	1.64±0.06	1.52±0.06	<0.001
Weight (kg)	56.3±12.3	60.1±12.6	51.3±10.0	<0.001
MUAC (cm)	25.6±4.1	26.1±4.2	25.0±4.0	0.163
BMI (kg m^{-2})	22.2±3.9	22.4±4.2	22.1±3.6	0.699
Comorbidities[b]				
Hypertension (%)	71 (62.8%)	40 (67.8%)	31 (68.9%)	<0.001
Diabetes mellitus (%)	33 (29.2%)	18 (30.5%)	15 (33.3%)	
Heart disease (%)	9 (8.0%)	5 (8.5%)	4 (8.9%)	
HD time (months)[c]	29 (15; 60)	29 (15; 60)	35 (16; 66)	0.481

HGS: Handgrip strength, MUAC: Mid upper arm circumference, BMI: Body mass index, HD: Hemodialysis, [a]Mean±Standard Deviation (SD), [b]Absolute and relative frequency for the categorical variables, [c]Median and inter-quartile range, [d]p-value for comparison between men and women by t-test for data expressed as Mean±SD, by Mann-Whitney test for data expressed as median (inter-quartile range), or by chi-square for categorical data

Table 2: Prevalence of malnutrition based on reference standard and HGS

	Total (N = 104) (%)	Men (N = 59) (%)	Women (N = 45) (%)	P*
SGA	34 (32.7)	13 (22)	21 (46.7)	0.008
DMS	44 (42.3)	20 (33.9)	24 (53.3)	0.047
NRS 2002	56 (53.8)	29 (49.2)	27 (60)	0.272
SNST	60 (57.7)	31 (52.5)	29 (64.4)	0.224
HGS	46 (44.2)	30 (50.8)	16 (35.6)	0.120

SGA: Subjective global assessment, DMS: Dialysis malnutrition score, NRS 2002: Nutritional risk screening 2002, SNST: Simple nutrition screening tool, HGS: Handgrip strength, *Significant for p<0.05

Table 3: Diagnostic accuracy of the cutoff of handgrip strength (HGS <u><</u>20 kg in men and <u><</u>10 kg in women) when identifying malnourished patients, compared with SGA, DMS, NRS 2002 and SNST, stratified by gender

	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value	AUC
Men						
SGA	76.9	56.5	61.0	33.3	89.7	0.667
DMS	70.0	59.0	62.7	46.7	79.3	0.645
NRS 2002	62.1	60.0	61.0	60.0	62.1	0.610
SNST	58.1	57.1	57.6	60.0	55.2	0.576
Women						
SGA	52.4	79.2	66.7	68.8	65.5	0.658
DMS	45.8	76.2	60.0	68.8	52.2	0.610
NRS 2002	37.0	66.7	48.9	62.5	41.4	0.519
SNST	34.5	62.5	44.4	62.5	34.5	0.485

SGA: Subjective global assessment, DMS: Dialysis malnutrition score, NRS 2002: Nutritional risk screening 2002, SNST: Simple nutrition screening tool, HGS: Handgrip strength, AUC: Area under curve

Table 4: Correlation of the handgrip strength (HGS) with anthropometric and nutritional screening tools, stratified by gender

	HGS			
	Men		Women	
	Correlation	P*	Correlation	P*
MUAC (cm)	0.471	<0.001	0.160	0.300
BMI (kg m^{-2})	0.215	0.102	-0.012	0.938
SGA	-0.424	0.001	-0.221	0.146
DMS	-0.454	<0.001	-0.195	0.200
NRS 2002	-0.301	0.020	-0.173	0.257
SNST	-0.316	0.015	-0.075	0.624

*p<0.05: Significant, MUAC: Mid upper arm circumference, BMI: Body mass index, SGA: Subjective global assessment, DMS: Dialysis malnutrition score, NRS 2002: Nutritional risk screening 2002, SNST: Simple nutrition screening tool, HGS: Handgrip strength, AUC: Area under curve

DISCUSSION

This study showed that HGS is an inaccurate indicator of nutritional status in male and female hemodialysis patients because of its inconsistency and low validity. HGS has high sensitivity compared to SGA and DMS but lower specificity among male patients. This shows the ability of HGS to detect more malnourished patients. HGS has a high NPV value but low PPV value. It also has a low area under the curve (AUC) value. However, an opposite result can be seen in female patients. HGS has higher specificity than sensitivity among women. This shows the ability of HGS to detect fewer patients who are malnourished. Low sensitivity means that the tests will miss many individuals who are malnourished, whereas low specificity suggests that the tests will put many people in the underweight group even if they actually have good nutritional status. A low sensitivity screening will increase some amount of 'false negatives', whereas, if screening has low specificity it will produce many 'false positives'. HGS has a low NPV, PPV and area under the curve (AUC) value.

There are a variety of possible explanations for the inaccuracy of HGS in assessing hemodialysis patients' nutritional status. First, there is no standardized technique for performing the HGS test, particularly related to measuring position, evaluation period, selection of measured arm and diagnostic criteria[3]. The timing and technique of HGS testing affect the results[13,14]. Furthermore, there is no fixed cutoff value to determine malnutrition status in the patient. Studies have suggested reference values based on representative population samples[15], but every region has differing population characteristics.

HGS can be used as morbidity and mortality parameters and also as an instrument to assess nutritional status[16]. A systematic review on the use of HGS in CKD patients on hemodialysis showed that HGS can be used to assess muscle mass-related nutritional status.[3] HGS also has high correlations with other nutritional assessment methods[17].

An instrument can be very sensitive but not specific or be very specific but not sensitive[18]. This study had similarities with a study conducted by Garcia *et al.*[19] and Alfitri[20] where HGS had higher sensitivity than specificity in the male group and had higher specificity than sensitivity in the female group.

SGA is used as a reference standard in this study because of its validity and reliability[21]. The National Kidney Foundation (NKF) Kidney Disease/Dialysis Outcomes and Quality Initiative (K/DOQI) recommended SGA as a nutritional status measurement tool for adult populations[4]. DMS is an advanced form of conventional SGA[6] and can be used to diagnose protein energy wasting (PEW)[7]. A study conducted by As'habi *et al.* [7]. showed that DMS has higher validity than conventional SGA[7]. NRS 2002 is a nutritional screening tool developed for hospital patients and was used in this study to validate HGS. In hemodialysis patients, only one study used NRS 2002 and it showed that NRS 2002 is a good predictor of hospital stay and death[22]. SNST is a new nutritional screening tool developed by Susetyowati *et al.*[9] SNST development was based on the lack of a precise nutritional screening tool that can be used in all populations, especially in Indonesia. A variety of studies assessing validity and reliability of SNST with hospital patients have shown its effectiveness[9].

Factors that affect handgrip strength in hemodialysis patients are sex, age, height, body mass, dominant arm, CKD complication, body fluid status, inflammation and level of carnitine[3]. Handgrip strength in male hemodialysis patients is generally higher than that in female patients. Age also affects handgrip strength and younger patients generally have higher handgrip strength than older patients[2,23-25]. Complications in CKD patients, such as anorexia, will decrease their handgrip strength[26].

HGS is related to body fluid status. Gastrointestinal edema, caused by excess fluids, can facilitate bacteria and endotoxin translocation. This increases pro-inflammation cytokines, such as TNF-α, which are responsible for protein catabolism and lead to a consequent decrease in handgrip strength[27]. Studies have also shown that HGS is correlated with C-reactive protein (CRP), another factor relevant to inflammation[23,28]. Lack of carnitine will also lead to low handgrip strength, especially in female patients[29].

In this study, HGS showed a negative correlation with all nutritional screening tools. In contrast, previous studies have shown consistent results for SGA[2]. However, HGS has a positive correlation with MUAC. This finding matched a study conducted by Garcia *et al.*[19].

The handgrip strength test involves the extension and supination of the triceps and brachioradialis muscles. These muscles, both located on the upper arm, affect handgrip strength. When mass and volume decrease in those muscles, grip strength decreases as well[30]. Reduction in MUAC can represent a reduction in muscle mass. A small MUAC represents low muscle mass[31] and therefore, low handgrip strength. However, mid-upper arm muscle circumference (MAMC) is a more precise tool to measure body composition and it portrays the patient's condition more accurately[32].

The present study has limitations. This study has a small sample size, which may affect the definition of the HGS cutoff and may not fully represent the population.

CONCLUSION

The HGS test appeared to be an inaccurate assessment of nutritional status in male and female CKD patients on hemodialysis in Indonesia. The HGS test's accuracy was limited by a lack of standardization in diagnostic criteria and the resulting lack of defined cutoff values for classifying muscle wasting. No previous studies have been conducted in Indonesia in this field, so cutoff values characteristic to the population of Indonesia were not available. Author recommend further studies to determine more precise HGS cutoff values for assessing nutritional status in hemodialysis patients according to characteristics of the population of each country with a sufficient sample size that can represent the population.

SIGNIFICANCE STATEMENT

This study discovers the HGS test to assess nutritional status in hemodialysis patients that can be beneficial for alternative nutritional assessment tools which one specific for dialysis patients. This study will help the researcher to determine the cutoff point that appropriate in each region. Thus, a new theory on this study will help the dietitians to assess nutritional status in dialysis patients which one more simple and quick than other nutritional assessment tools.

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