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Original article

Psychometric properties of Body Mass Index in screening malnutrition of COPD inpatients admitted at Nguyen Tri Phuong Hospital, Vietnam: a cross-sectional study

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Abstract: ***Introduction*****:** This study assessed the validation of Body Mass Index (BMI) against Subjective Global Assessment (SGA), and identify the prevalence of malnutrition and its associated factors in Chronic Obstructive Pulmonary Disease (COPD) inpatients at Nguyen Tri Phuong Hospital, Ho Chi Minh City, Vietnam. ***Methods*****:** A cross-sectional study was conducted to consecutively select COPD inpatients based on medical records and consultancy with doctors. A structured questionnaire was designed to collect socio-demographic characteristics, health status and comorbidities, nutritional status, and handgrip strength. Nutritional status was assessed using SGA and BMI. Handgrip strength was measured using a hand dynamometer. Health status was collected from medical records. ***Results*****:** The mean age of 83 COPD inpatients recruited in this study was 67 (SD=10.4) years. Most of the sample population was ≥60 years old (75%), male (86%), Kinh ethnic (89%), married (72%), not currently working (70%), and less than junior high school (81%). Nearly 68% had at least one comorbidity and 27% were active smokers. The mean handgrip strength was 21.6 kg (SD=8.7), and mean weight was 53.9 kg (SD=10.0). The mean BMI was 20.4 kg/m^2 (SD=3.4) with 58% having BMI <21 kg/m^2. SGA provided the prevalence of malnutrition of 65%. Age-group, BMI and handgrip strength were associated with malnutrition. A BMI cut-off point of <21 kg/m^2 provided the highest ROC area of 84% (95%CI: 76%-92%). ***Conclusion*****:** Malnutrition is common in COPD inpatients. This study confirms findings of previous studies that a BMI cut-off point of <21 kg/m^2 was sensitive and specific for screening malnutritional risk at bedside.

Keywords: subjective global assessment; ROC area; chronic obstructive pulmonary disease; non-communicable diseases; Ho Chi Minh City.

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD), a progressive and treatable lung disorder, is a major public health concern. The global prevalence of COPD in 40-year and older population was 12% that was 251 million cases in 2016 [1]. COPD has been the top ten causes of global deaths since 2002 in both developed and developing countries [2]. It is projected that COPD will account for 3.1% of total Disability-Adjusted Life Years (DALYs) in 2030 [2]. COPD caused 3.2 million deaths, accounting for 5% of total deaths worldwide in 2015, of which 90% occurs in low and middle-income countries [1].

COPD patients suffer a high risk of malnutrition, particularly in those with severe COPD. It was estimated that

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the prevalence of malnutrition in COPD patients was 40%-80% [3-5]. Current studies indicated that malnutrition in COPD patients not only increases the severity of COPD, but also increases the risk of new exacerbations, hospital readmission and mortality rate [6-11]. Moreover, malnutrition negatively impacted on disease prognosis and reduced forced respiratory volume in one second (FEV1), diffusing and locomotive capacity of the lung, and decreased quality of life of COPD patients [12, 13]. Therefore, improving nutritional status of COPD patients helps reduce blood CO_2 levels and increase physical and pulmonary capacity and quality of life [14-16].

Early diagnosis of malnutrition increases the effectiveness of treating COPD; however, there was no gold standard for diagnosing malnutrition [17]. "*Malnutrition refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients*" [18]. Body Mass Index (BMI) which is the most popular method to assessing nutrition status but mostly depends on weight and height measures. Therefore, its accuracy is affected by people's comorbidities and disabilities [19]. Subjective Global Assessment (SGA) is a simple, inexpensive, and a valid and reliable tool for assessing and screening nutritional status of patients; and has been widely used in many studies worldwide including Vietnam [20-26].

Vietnam has a quick aging population of 96.5 million persons [27]. The prevalence of COPD 40-year and older Vietnamese was 7.1% in men and 1.9% in women in 2016 [28]. The prevalence of COPD in Vietnamese 35+ years was 6.7% which is the highest in Asia Pacific area [29]. There have been two studies conducting in different hospitals in Vietnam to identify the prevalence of malnutrition in COPD outpatients [26, 30]. Those studies found that malnutrition was a considerable condition in Vietnamese COPD patients. It was reported that 45%-75% COPD outpatients were identified as malnutrition [26, 30].

COPD malnutrition inpatients are more likely to have worse treating outcomes, higher mortality rate, and higher readmission rate and to stay longer in the hospital [6-11, 31]. Because COPD inpatients suffer high risks to malnutrition and worse health outcomes, this study responded to the urgent need for a good tool to screen malnutrition so that early intervention can be used to improve chances of reducing risk of mortality, getting better health outcomes, and improving quality of life [14-17]. This study aimed to assess the psychometric properties of Body Mass Index (BMI) against Subjective Global Assessment (SGA) in screening malnutrition; and to add more data on the prevalence of malnutrition in COPD inpatients and its associated factors.

2. MATERIALS AND METHOD

2.1. Study settings and design

A cross-sectional study was conducted at Nguyen Tri Phuong Hospital (NTPH), a general hospital, located in District 5, Ho Chi Minh City, Vietnam from January to June 2020. This grade one provincial hospital has 800 beds. The hospital's Department of Respiratory Medicine has 60 beds and takes care of 60 COPD patients per month.

2.2. Participants and sampling

A researcher approached and screened all medical records of COPD inpatients admitted to the Department of Respiratory Medicine in the first 48 hours between January and June 2020. Patients were included in the study if they had a predicted FEV1 <80% and FEV1/FVC <0.7 within 6 months and diagnosed with COPD by medical doctors. Patients were excluded if they had a lung cancer, any other malignant diseases, Glasgow ≤10, a hearing loss, a mental disorder, a dementia, or inability to answer study questions. COPD patients received nutritious intervention were also excluded.

2.3. Data collection and tools

Data on socio-demographic characteristics, health status and comorbidities, nutritional status, and handgrip strength were collected using a structured questionnaire.

Socio-demographic data included age group (<60, ≥60), gender (male, female), ethnicity (Kinh, Hoa), marital status (married, others), working status (not working, currently working), education level (<grade 10, ≥grade 10) and household economic status (non-poor, poor).

Health status included data on comorbidity (yes, no), respiratory failure status (yes, no) and exacerbation of COPD (yes, no) that were collected from medical records. Comorbidity was yes if patients have one of the following diseases: hypertension, diabetes, chronic heart failure, coronary artery disease, chronic renal failure, or any other chronic disease. Exacerbation was yes if a patient suffered it during the hospital admission. A patient suffered a respiratory failure status was coded as yes.

Weight (kg) and height (cm) were measured following guidelines of World Health Organization [32]. Weight was measured to the nearest 0.1 kg using a BC-543 electronic scale. Height was measured to nearest 0.1 cm using a stadiometer with a fixed vertical backboard and an adjustable head piece. Body Mass Index (BMI) was calculated as weight divided by height squared (kg/m^2) and categorized into six BMI thresholds (<16.5, <18.5, <19, <20, <21, <22) [26, 32].

Nutritional status was assessed by a trained researcher using Subjective Global Assessment (SGA), consisted of medical history and clinical examination [33]. Medical history collected data on nutrient intake, weight changes, symptoms affecting oral intake, functional capacity, and metabolic requirement. Clinical examination was loss of body fat, loss of muscle mass, and presence of edema/ascites. SGA categorized as SGA-A (well-nourished), SGA-B (mild malnourished), and SGA-C (severe malnourished).

Handgrip strength (kg) was measured using Handgrip JAMA Hand Dynamometer. A patient was asked to hold the dynamometer in a dominant hand with its arm at squared angles and its elbow by the side of patient's body. Each patient was tested three times for an average value. Muscular dysfunction was yes if handgrip strength was below normal ranges set by reference values from Korean population [34].

2.4. Statistical analysis

Data were entered using Epidata3.0 and analyzed using Stata14.0. Categorical variables were expressed as frequency and percentage. Mean and standard deviation (SD) were applied to continuous variables.

Fisher exact test was used to test the association between age-group, gender, ethnic group, marital status, working status, education level, household economic status, smoking status, comorbidity, exacerbation of COPD, and acute respiratory failure with SGA classification. One-way analysis of variance was used to compare mean difference in weight (kg), BMI (kg/m^2) and handgrip strength (kg) across SGA classification.

A p-value <0.2 was used to select explanatory variables entering a multivariate Poisson regression with robust variance estimator. Variable with the highest p value was removed until a stopping threshold of 0.1 was reached [35]. Prevalence ratio (PR) and its 95% confidence intervals (95%CI) was calculated for each pair of relationship.

Sensitivity, specificity, positive predictive value, negative predictive value, and Receiver Operating Characteristic (ROC) area of BMI thresholds in diagnosing malnutrition versus SGA classification were calculated using contingency table. The appropriate threshold of a test was selected based on its ROC area. A threshold that provided higher value of ROC area meant that it had better ability to classify status [36]. A ROC area ≥ 0.5 was acceptable for a screening and diagnostic test [36].

2.5. Ethical consideration

This study was approved by the Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City (Approval No. 37/DHYD-HDĐĐ) and the Ethics Committee of Nguyen Tri Phuong Hospital (Approval No. 77/NTPQLCL). Each participant was asked to sign in an informed consent before any data collected.

3. RESULTS

Table 1. Demographic and health characteristics of COPD inpatients in the study sample (n=83)

Characteristics	N (%)	SGA-A N (%)	SGA-B N (%)	SGA-C N (%)	p-value
Age group					
< 60	21 (25.3)	14 (66.7)	7 (33.3)	0 (0)	<0.01
≥ 60	62 (74.7)	15 (24.2)	39 (62.9)	8 (12.9)	
Gender					
Female	12 (14.5)	3 (25.0)	8 (66.7)	1 (8.3)	0.80
Male	71 (85.5)	26 (24.8)	38 (53.5)	7 (9.9)	
Ethnic group					
Hoa	9 (10.8)	4 (44.4)	4 (44.4)	1 (11.1)	0.68
Kinh	74 (89.2)	25 (37.8)	42 (56.8)	7 (9.5)	
Marital status					
Married	60 (72.3)	25 (41.7)	31 (51.7)	4 (6.7)	0.06
Single/widow/separated	23 (27.7)	4 (17.4)	15 (65.2)	4 (17.4)	
Working status					
Not working	58 (69.9)	15 (25.9)	36 (62.1)	7 (12.1)	0.03
Currently working	25 (30.1)	14 (56.0)	10 (40.0)	1 (4.0)	
Education level					
< Grade 10	36 (43.4)	11 (30.6)	20 (55.6)	5 (13.9)	0.47
≥ Grade 10	47 (56.6)	18 (38.3)	26 (55.3)	3 (6.4)	
Household economic status					
Non-poor	46 (55.4)	19 (41.3)	23 (50.0)	4 (8.7)	0.37
Poor	37 (44.6)	10 (27.0)	23 (62.2)	4 (10.8)	
Smoking status					
Non-smoker	11 (13.3)	3 (27.3)	7 (63.6)	1 (9.1)	0.74
Ex-smoker	50 (60.2)	16 (32.0)	28 (56.0)	6 (12.0)	
Active smoker	22 (26.5)	10 (45.6)	11 (50.0)	1 (4.6)	
Comorbidity					
No	27 (32.5)	7 (25.9)	15 (55.6)	5 (18.5)	0.13
Yes	56 (67.5)	22 (39.3)	31 (55.4)	3 (5.4)	
Exacerbation of COPD					
No	16 (19.3)	3 (18.8)	12 (75.0)	1 (6.3)	0.24
Yes	67 (80.7)	26 (38.8)	34 (50.8)	7 (10.5)	
Acute respiratory failure					
No	50 (60.2)	20 (40.0)	30 (60.0)	0 (0)	<0.01
Yes	33 (39.8)	9 (27.3)	16 (48.5)	8 (24.2)	
Handgrip strength (kg) (mean ± SD)	21.6±8.7	25.9±8.9	20.1±7.8	14.6±6.0	<0.01[a]
Weight (kg) (mean ± SD)	53.9±10.0	63±7	51±8	40±4	<0.01[a]
BMI (kg/m^2) (mean ± SD)	20.4±3.4	23.4±2.3	19.4±2.4	15.1±1.2	<0.01[a]

SGA: Subjective Global Assessment, SGA-A (well-nourished; normal), SGA-B (mildly/moderate malnourished; some progressive nutritional loss), SGA-C (Severely malnourished; evidence of wasting and progressive symptoms)
**missing data due to incomplete records*
All used Fisher exact test, except stated other
[a] *One-way analysis of variance (ANOVA)*

A total of 96 COPD inpatients were approached, of these, eight refused to participate, one did not complete the questionnaire, two had cancer, and two were unable to measure weight and height that made the final sample of 83 COPD inpatients (the participation rate was 86%). The mean age was 67 years (SD=10.4). Most patients were ≥60 years old (74.7%), male (85.5%), not working (69.9%), Kinh (89.2%), married (72.3%), and had a junior high school and lower (80.7%). A half of the sample was non-poor (55.4%).

The percentage of ex-smokers and active smokers was 60.2% and 26.5%, respectively. The percentage of patients having at least one comorbidity was 67.5%. Hypertension was the most common (94.6%), following by diabetes (25%), heart failure (17.9%), coronary artery diseases (7.1%) and chronic renal failure (3.6%). COPD exacerbation was reported in 80.7% patients, of which, 6.2% were mild, 67.7% were moderate and 26.1% were severe. The percentage of patients having acute respiratory failure was 39.8%. The characteristics of 83 COPD patients were described in Table 1.

Older COPD inpatients and those with acute respiratory failures are more likely to have malnutrition compared to younger ones and those without acute respiratory failures (p<0.01, Fisher exact test). Whereas those who are working are less likely to have malnutrition compared to those are not currently working (p=0.03, Fisher exact test).

The mean weight and BMI were 53.9 (SD=10) kg and 20.4 (SD=3.4) kg/m^2. There were statistically significant differences in weight (p<0.01, ANOVA) and BMI (p<0.01, ANOVA) across SGA. On average, COPD inpatients with SGA-A had 12 kg heavier than those with SGA-B (p<0.01, Bonferroni test) and 23 kg heavier than those with SGA-C (p<0.01, Bonferroni test). Similarly, COPD inpatients with SGA-A had four points higher than those with SGA-B (p<0.01, Bonferroni test) and eight points higher than those with SGA-C (p<0.01, Bonferroni test) in BMI.

The handgrip strength was 21.6 (SD=8.7) kg. Almost patients (95%) were considered as muscular dysfunction. The mean handgrip strength was a statistically significant difference across SGA group (p<0.01, ANOVA). The handgrip strength was 5.7 kg lower in COPD inpatients with SGA-B compared to those with SGA-A (p=0.01, Bonferroni test).

The percentage of COPD inpatients classified as well-nourished (SGA-A), mild/moderate malnutrition (SGA-B) and severe malnutrition (SGA-C) was 34.9%, 55.4%, and 9.6%, respectively.

Table 2. Multivariate Poisson regression for measuring association between associated factors with malnutrition (n=83)

Malnutrition by SGA	PR	95%CI	p-value
Age group			
< 60 years	1		
≥ 60 years	1.28	1.14; 1.44	<0.01
BMI (kg/m^2)	0.93	0.91; 0.94	<0.01
Handgrip strength (kg)	0.99	0.99; 1.00	<0.01

PR: Prevalence Ratio; 95%CI: 95% Confidence Interval
A multivariate Poisson regression with robust variance estimator using backward selection adjusted for age group, marital status, working status, comorbidities, acute respiratory failure, handgrip strength, weight, and Body Mass Index (BMI). Malnutrition was classified using SGA (Subjective Global Assessment).

Table 3. Sensitivity (Sens), Specificity (Spec), Positive Predictive Value (PPV), Negative Predictive Value (NPV), and ROC area and its 95% Confidence Interval (95%CI) of Body Mass Index (BMI) compared to Subjective Global Assessment (SGA) in diagnosing malnutrition (n=83)

BMI	N (%)	Sens (%)	Spec (%)	PPV (%)	NPV (%)	ROC area (95%CI)
<16.5	9 (10.8)	17	100	100	39	0.58 (0.53; 0.63)
<18.5	27 (32.5)	50	100	100	52	0.75 (0.68; 0.82)
<19	31 (37.4)	57	100	100	56	0.79 (0.72; 0.85)
<20	43 (51.8)	74	90	93	65	0.82 (0.74; 0.90)
<21	48 (57.8)	82	86	92	71	0.84 (0.76; 0.92)
<22	54 (65.1)	87	76	87	76	0.81 (0.72; 0.91)

In the multivariate model (Table 2), COPD inpatients aged 60 and older are 1.28 times more likely to have malnutrition compared to those aged less than 60 (PR=1.28, 95%CI: 1.14-1.44, p<0.01). The risk of getting malnutrition decreases by 7% in each BMI unit increase (PR=0.93, 95%CI: 0.91-0.94,

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p<0.01) and by 1% in each handgrip strength unit increase (PR=0.99, 95%CI: 0.99-1.00, p<0.01).

The percentage of COPD inpatients with different BMI thresholds was presented in Table 3. One in ten COPD inpatients had BMI<16.5 kg/m^2. One third of COPD inpatients had BMI <18.5 kg/m^2 whereas two thirds had BMI <22 kg/m^2. The ROC area of BMI<16.5 kg/m^2 was the lowest 0.58 (95%CI: 0.52-0.63) and BMI <21 kg/m^2 was the highest 0.84 (95%CI: 0.76-0.92).

4. DISCUSSION

This study found that 65% COPD inpatients suffering malnutrition, in which 55.4% was moderate and 9.6% was severe. This prevalence was higher than a figure of 45% (31% were moderate and 14% were severe) of a previous study conducted on 29 outpatients in Ho Chi Minh City in 2014 by Hogan et al. [26]. Another study was conducted on 168 COPD outpatients in Hanoi, the capital city of Vietnam, provided a figure of 75% malnutrition (42% were moderate and 33% were severe) [30]. The severity of COPD and the fact that this study focused on inpatients may explain the difference in prevalence of malnutrition [26, 30, 31]. A study investigated 180 medical records reported that the prevalence of malnutrition was 78% of COPD inpatients in Hong Kong [31] and that prevalence was 83% (59.5% were moderate and 23.5% were severe) in a study conducted on 106 Indian inpatients [3].

This study found that inpatients aged 60 years and older were more likely to have malnutrition that was consistent with previous studies [26, 30]. Many comorbidities make older patients to eat less, and the use of certain drugs can also lead to anorexia in these old patients. In addition, a decrease in muscle mass by age, particularly after the age of 60, that also contributes to the fact that older patients are more likely to have malnutrition than younger ones in our study [37]. Our study also identified that those who are currently working are less likely to have malnutrition compared to those are not currently working in univariate analysis, but the association was disappeared in the multivariate analysis. Those who are not currently working are older and often experience a decrease in muscle mass by age leading to poor nutritional status. Also, as they are not currently working, they have economic difficulties leading to poor quality of their meals that increase the risk of malnutrition.

Handgrip strength was inversely associated with malnutrition in this study. Handgrip strength is a bedside biomarker of muscle function that can be used to assess nutritional variation [38]. Muscle depletion is a common phenomenon in COPD patients [39]. Losing muscle mass not only affects exercise capacity, poor quality of life, but also affects daily activities and recurrent acute exacerbation [39]. Our study highlighted a high prevalence of muscular dysfunction in COPD patients and a significant difference across SGA groups. In addition, muscle loss is known to occur in patients across BMI classifications [40]. In fact, a study demonstrated that muscle depletion was occurred in all patients with BMI <21 kg/m^2 [26]. Therefore, an early clinical determination of muscle loss by developing a new cut-off point and widely applying muscular dysfunction diagnosis methods is essential to early detect malnutrition in COPD patients, thereby providing timely and useful interventions for these patients, particularly in the context that many hospitals in Vietnam use BMI cut-off point of <18.5 kg/m^2 to assess nutritional status in COPD patients that can miss a considerable number of malnutrition patients.

According to World Health Organization BMI classification [32], our study identified 32.5% were underweight patients (BMI <18.5 kg/m^2), of which prevalence of severe underweight patients were 10.8% (BMI <16.5 kg/m^2) and that of patients with moderate underweight were 22.2% (16 ≤ BMI <18.5 kg/m^2). This result was similar to the one by Yuceege (26.7%) [5] and Hogan (26%) [26] but lower than a study by Gupta et al. (59.5%) [3]. This is probably because the prevalence of undernutrition in the Vietnamese general population has sharply decreased from 25% in 2000 [41] to 9% in 2015 [42]. The average BMI of the sample was 20.4 kg/m^2 (SD 3.4) and 58% had BMI <21 kg/m^2 suggested that patients with BMI <21 kg/m^2 should have nutritional assessment (ROC=0.84, 95%CI: 0.76-0.92). This was consistent with a suggestion of a BMI cut-off point by Hogan [26] and American Thoracic Society and European Respiratory Society [43].

Many studies suggested that BMI is not sensitive to measure nutritional status of different phenotypes and clinical stages of COPD patients [30, 44]. The SGA assesses changes in anthropometry, diet, gastrointestinal conditions, functional performance, and physical changes and is considered as a gold standard for assessing nutritional status in COPD patients, including those hospitalized due to acute exacerbation [33]. However, this study found that a BMI cut-off point of <21 kg/m^2 demonstrated a good sensitivity of 82% and specificity of 86% against SGA. This result was similar to a previous study conducted on Vietnamese COPD patients, which shows a high sensitivity of 100% and a specificity of 94% against the SGA [26]. A BMI cut-off point of <22 kg/m^2 provided the highest sensitivity (87%) with an acceptable ROC area (ROC=81%; 95%CI: 72% to 91%). Park et al. suggested that a screening test should have a high sensitivity [36]. However, a BMI cut-off point of <21 kg/m^2 has previously been recommended as a means of identifying patients who are at nutritional risk and muscle depletion [26, 43]. This study found that a BMI cut-off point of <21 kg/m^2 provided the best ROC area (ROC=84%; 95%CI: 76% to 92%). Therefore, it is suggested a BMI cut-off point of <21 kg/m^2 could be used for screening purpose.

Smoking has been found to increase the risk of malnutrition in some studies [30, 45, 46]. A mechanism on how smoking increases the risk of malnutrition was clearly explained in previous studies that tobacco's nicotine decreases body weight by increasing metabolic rate, decreasing metabolic efficiency through releasing eating-reduce-hormones, and decreasing energy absorption [30, 45]. However, this study did not reveal any impacts of smoking on the risk of malnutrition in both univariate and multivariate analysis that was consistent with a previous study conducted in Ho Chi Minh City [26]. One study conducted in the north of Vietnam concluded that smoking increases the risk of malnutrition; however, this association was on borderline significance (OR=1.04, 95%CI: 0.99-1.10) [30].

This cross-sectional study had some limitations. Firstly, it was conducted on 83 COPD inpatients at one hospital in Ho Chi Minh City. The sample was homogenous; however, its generalizability to broaden population was limited. Secondly, the study failed to assess the impact of the COPD severity and phenotypes and underlying causes of comorbidities on malnutrition as those data were missed. However, this study provided hospital managers, clinical practitioners, and nutritionists useful information for developing nutrition intervention strategy at bedside for Vietnamese COPD inpatients.

Conclusion

In conclusion, malnutrition is a common health problem in this sample population. It is suggested that a BMI cut-off point of <21 kg/m^2 should be combined with SGA to screen malnutritional risk of COPD inpatients, particularly in those aged 60 years and older to ensure that they are timely intervened for the optimal health outcomes.

CONFLICT OF INTEREST

No conflicts of interest.

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AUTHOR CONTRIBUTIONS

TPU conceptualized the study. TPU, PTLA and HNVA contributed to develop the study design. TPU collected data and TVT supported in data collection. TPU, KGT did analysis and drafted the manuscript. All authors contributed to data interpretation, and critically revised and approved the final manuscript.

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