

Association between neutrophil to lymphocyte ratio, handgrip strength and nutritional status in geriatric patients

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Abstract

Purpose – This study aims to examine the relationship between neutrophil to lymphocyte ratio (NLR), handgrip strength (HGS) and nutritional status in non-critically ill patients and outpatients.

Design/methodology/approach – A cross-sectional study was conducted on 80 geriatric patients. Nutritional status was evaluated using the Mini Nutritional Assessment Short Form, Geriatric Nutritional Risk Index, some anthropometric and biochemical parameters. NLR was calculated from the complete blood count results. Data were analyzed using SPSS 24.0.

Findings – While 38.3% of patients were malnourished or at risk of malnutrition, 61.7% had normal nutritional status. Mini Nutritional Assessment Short Form was not correlated with NLR, whereas it showed a weak positive correlation with HGS. According to the logistic regression analysis, age, HGS, hemoglobin and platelet to lymphocyte ratio were significant independent factors for predicting malnutrition or risk of malnutrition. The receiver operator characteristic curve analysis showed that the optimum HGS cut-off point for patients with malnourished or at risk of malnutrition was 13.2. In conclusion, HGS was associated with the nutritional status. NLR was not associated with nutritional status but associated with nutritional risk.

Originality/value – It is well known that malnutrition is a serious health problem among older adults, and it is important to assess the nutritional status of older adults because of the adverse health effects. In addition, to the best of the authors' knowledge, this is the first study to determine the relationship between NLR, HGS and nutritional status in non-critically ill patients and outpatients.

Keywords Nutritional status, Handgrip strength, Neutrophil to lymphocyte ratio, Elderly, Malnutrition

Paper type Research paper

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Introduction

Malnutrition is a serious health problem among older adults. It is defined by the European Society for Clinical Nutrition and Metabolism (ESPEN) as “a condition resulting from a lack of intake and uptake of nutrition, resulting in altered body composition, reduced physical and mental functions, and impaired clinical outcome from disease” (Cederholm *et al.*, 2017). Adequate nutritional status plays a key role in maintaining a healthy life and is, thus, a valuable prerequisite for healthy aging. However, adequate nutritional status may not be maintained because of reasons such as decreased appetite, digestive problems, poor taste and smell, swallowing and chronic diseases in older adults (Chang *et al.*, 2021). According to the United Nations report, approximately 9% of people globally are 65 years or older in 2019, and this will reach 23% by 2100 [United Nations (UN), 2019]. Currently, the prevalence of high risk of malnutrition among older adults in Europe is reported to range from 8.5% to 28.0% (Leij-Halfwerk *et al.*, 2019). Malnutrition generally causes geriatric syndromes such as sarcopenia, frailty and fatigue in older adults and is also associated with increased morbidity and mortality in both acute and chronic diseases. Besides, it is considered a serious burden on the health-care system (Cederholm *et al.*, 2017). Therefore, it is essential to prevent malnutrition by periodically assessing the nutritional status of older adults.

Malnutrition is a common condition often overlooked by clinicians in geriatric patients. The usage of screening tools to predict nutritional status can significantly contribute to improving clinical outcomes and reducing health-care costs in patients at risk of malnutrition. Although a wide variety of screening tools exist to predict malnutrition risk, the Mini Nutritional Assessment Short Form (MNA-SF) is recommended in practice guidelines for the elderly (Guigoz and Vellas, 2021). However, there is no accepted gold standard screening tool to determine the nutritional status of individuals and classify malnutrition risk (Kokkinakis *et al.*, 2021). Separately, nutritional screening is not sufficient for a full nutritional assessment. Nutritional assessment is the systematic process of providing information to make decisions about the characteristics and causes of nutrition-related health problems (Pekcan, 2012). As a result, nutritional status should be assessed with nutrition-based indicators such as clinical symptoms, diet history, BMI, skinfold thickness, serum albumin, urinary creatinine and handgrip strength (HGS) (Pekcan, 2012; Hasheminejad *et al.*, 2016).

The etiology of malnutrition is complex, and to date, several risk factors have been identified that contribute to the development of malnutrition. A consensus committee of the USA and European clinical nutrition community (ESPEN and ASPEN) has suggested three sub-definitions for malnutrition in adults. The sub-descriptions are “pure chronic starvation without inflammation,” “low-grade chronic inflammation-associated malnutrition” and “acute disease-related malnutrition with marked inflammatory” (Jensen *et al.*, 2010). Rising knowledge during the coronavirus disease 19 (COVID-19) pandemic has indicated that aging accompanies low-grade chronic inflammation, potentially increasing the risk of malnutrition (Rothenberg, 2021). This silent and everlasting inflammation is known to trigger satiety regions in the hypothalamus (Pourhassan *et al.*, 2018). The loss of appetite and early satiety observed in the elderly has been described as the “anorexia of aging” and results in subsequent undernutrition, sarcopenia and immunosuppression (Cox *et al.*, 2019). It is, therefore, reasonable to interpret laboratory inflammatory biomarkers to better understand the contribution of inflammation to nutritional status in the elderly.

Neutrophil to lymphocyte ratio (NLR) is thought to be a simple and reliable biomarker of systemic inflammation and can be easily calculated from complete blood count (CBC) in patients. Literature findings have shown that NLR is not only a marker of systemic inflammation but also a prognostic predictor in several diseases, such as cancer and chronic

kidney disease (Han *et al.*, 2022; Silva *et al.*, 2020). Despite the lack of research, it has also been suggested that NLR may be a practical marker in the nutritional assessment of geriatric patients (Kaya *et al.*, 2019). However, it should be known that age, gender, exogenous steroid use, hematological disorders and chemotherapy can significantly affect NLR (Bedel and Korkut, 2021; Buonacera *et al.*, 2022). Studies have suggested that NLR is associated with nutritional risk in critical illness (Siqueira *et al.*, 2021; Wang *et al.*, 2022). However, it is not clear whether the increase in NLR is a cause or a consequence of malnutrition in older adults.

In addition, HGS, a commonly used tool for assessing muscle function, has been regarded as an indicator of nutritional status (Auyeung *et al.*, 2020; Hasheminejad *et al.*, 2016). It is recognized as a rapid, non-invasive, cost-effective method (Bhasin *et al.*, 2020). It was observed that patients with malnutrition or risk of malnutrition had lower HGS (Akbar and Setiati, 2018; Mendes *et al.*, 2020). However, studies on non-critically ill patients and outpatients have been quite limited about this issue. Furthermore, these studies did not evaluate the relationship between HGS and NLR. Therefore, the aim of this study was to examine the relationship between NLR, HGS and nutritional status in non-critically ill patients and outpatients. Moreover, we tried to propose a cut-off point for HGS as a predictor of malnutrition in these patients.

Materials and methods

Study design and subjects

This descriptive and cross-sectional study was conducted on 80 geriatric patients who were admitted to the gastroenterology, physical therapy and rehabilitation, endocrinology and general internal medicine clinic and polyclinic of a university hospital between December 2021 and July 2022.

The sample size was calculated using the G*Power 3.1 software with $\alpha = 0.05$ and test power = 0.95. A similar study was used for the effect size (d) in the sample analysis (Kaya *et al.*, 2019). We found a sample size minimum of 49 patients. Inclusion criteria were patients who agreed to participate in the study, were of both sexes, had ages ≥ 65 years and did not have limb amputation or neurological motor deficits.

Exclusion criteria were patients who did not agree to participate in the study, had ages < 65 years, had albumin infusion administration, edema, cancer and/or history of chemotherapy/radiotherapy application, immunodeficiency, acute or chronic infections, chronic inflammatory conditions (such as rheumatic diseases, malignancies and hematological diseases), diseases or drug use that may affect NLR (such as corticosteroid, nebivolol and immunosuppressant), acute myocardial infarction, valvular heart disease, renal or hepatic dysfunction or coronary revascularization, history of revascularization in the past six months and smoking in the past three months. In addition, we excluded those with problems affecting HGS (such as stroke, carpal tunnel syndrome, etc.) and arm fracture based on medical records. Therefore, 20 patients were excluded, and 60 were eligible for the study.

Demographic characteristics (sex, age, alcohol use, smoking and comorbidities), nutritional status, some anthropometric measurements (height, body weight, HGS, middle-upper arm circumference [MUAC]) and biochemical parameters of patients were recorded.

All procedures were performed according to the Principles of the Declaration of Helsinki. The study was approved (Approval number: TÜTF-GOBAEK2021/456) on 29-Sep-2021. Written and verbal informed consent was obtained from all patients.

Assessment of nutritional status

The nutritional status of patients was evaluated with MNA-SF and Geriatric Nutritional Risk Index (GNRI). Mini Nutritional Assessment (MNA) is a screening questionnaire to assess nutritional status, which was developed in collaboration with the University of Toulouse, New Mexico School of Medicine and the Nestle Research Center of Switzerland in 1994 (Guigoz *et al.*, 1996). However, the validity of MNA-SF was evaluated by Rubenstein *et al.* (2001). On the MNA-SF scale, a score of <7 points is defined as malnutrition, 7–11 points is defined risk of malnutrition and ≥ 11 points is considered normal nutrition (Sarıkaya *et al.*, 2015).

GNRI is an index to predict nutritional risk, which was developed by Bouillanne *et al.* (2005). The GNRI was calculated using the following formula:

$$\text{GNRI} = [1.489 \times \text{albumin (g/L)}] + [41.7 \times (\text{patient's body weight / ideal weight})]$$

GNRI classified as a score of <92 points is defined as severe/moderate risk of nutrition, 92–98 points low risk of nutrition and ≥ 98 points at no risk of nutrition (Bouillanne *et al.*, 2005).

Anthropometric measurements

An electronic weighing scale and a stadiometer were used to determine body weight (kg) and height (m) (ADE, model: M304641-01). BMI was calculated by dividing body weight (kg) by body height squared (m^2) [World Health Organization (WHO), 2004].

The MUAC was measured with a non-stretch plastic tape at the midpoint of the left upper arm between the olecranon and acromion process (Pekcan, 2012).

The HGS was measured with a Jamar dynamometer (Cambry, model: EH101) and was measured in kilograms with a 0.1-kg resolution. The dominant and non-dominant hands were measured twice, and the averages were calculated and recorded in kilograms. All anthropometric measurements were performed by the same researcher for the lack of bias.

Biochemical parameters

Blood samples were collected after 12 h of fasting. Patient medical records were used to obtain CBC, albumin, C-reactive protein (CRP) and other laboratory parameters at the time of admission. The NLR values of all patients were calculated by dividing the absolute neutrophil count by the absolute lymphocyte count.

Statistical analysis

Data were analyzed using the SPSS Statistics program, version 24.0 (Statistical Package for the Social Sciences, Inc.; Chicago, IL). The distribution of the variables was verified by the Kolmogorov–Smirnov test. Data were expressed as numbers, mean (SD) or median, depending on the distribution of the variable. To compare measured variables malnourished or at risk of malnutrition and normal nutritional status, the student's *t*-test was used for those with normal distribution, and Mann–Whitney U-test was used for those without normal distribution. The chi-square test was used for categorical variables. Bivariate correlation coefficients (*r*) were determined using Spearman's correlation coefficient. A receiver operator characteristic curve was constructed to reveal an association between HGS and malnourished or risk of malnutrition status. Binary logistic regression was carried out to identify predictors of being categorized as malnourished or at risk of malnutrition. The *p*-value <0.05 was considered statistically significant.

Results

Table 1 shows the demographic characteristics of patients. A total of 60 (31.7% of male and 68.3% female) elderly were included in the study, the mean age was 70.8 ± 5.5 years for men, 70.8 ± 6.4 years for women and the total mean age was 70.8 ± 6.1 years. Most of the patients (76.7%) graduated from primary school and were married (71.7%). There were no patients who use alcohol and most of them did not smoke (68.3%). The presence of chronic disease was in 90.0% of the patients, and hypertension is the most prevalent at 63.3%. According to MNA-SF results, 23 patients were malnourished or at risk of malnutrition

Parameters	<i>n</i>	Total (n: 60) %
<i>Age (years)*</i>		70.8 ± 6.1
<i>Sex</i>		
Male	19	31.7
Female	41	68.3
<i>Education status</i>		
Illiterate	5	8.3
Primary school	46	76.7
High school	2	3.3
University or higher	7	11.7
<i>Marital Status</i>		
Married	43	71.7
Single	17	28.3
<i>Alcohol use</i>		
Yes	–	–
No	60	100
<i>Smoking status</i>		
Yes	3	5.0
No	41	68.3
Stop smoking	16	26.7
<i>Chronic disease^d</i>		
Yes	54	90.0
No	6	10.0
Diabetes	25	41.7
Hypertension	38	63.3
Other diseases	14	23.3
<i>MNA-SF classification</i>		
<7 points (Malnourished)	3	5.0
7–11 points (Risk of malnutrition)	20	33.3
≥11 points (Normal nutritional status)	37	61.7
<i>GNRI classification</i>		
< 92 points (Severe/moderate risk of nutrition)	1	1.7
92–98 points (Low risk of nutrition)	6	10.0
≥98 points (No risk of nutrition)	53	88.3

Table 1.
Demographic
characteristics of the
patients (n: 60)

Notes: *Values are shown as Mean ± SD. ^dValues were calculated for more than one disease in the same patient. MNA-SF: Mini Nutritional Assessment-Short-Form and GNRI: Geriatric Nutritional Risk Index
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(38.3%), whereas 37 patients had normal nutritional status (61.7%). However, according to GNRI, 7 patients were at severe/moderate or low risk of nutrition (11.7%), while 53 patients were at no risk of nutrition (88.3%).

The mean age was 74.1 ± 7.4 years in patients with malnutrition and at risk, and 68.7 ± 3.9 years in patients with normal nutritional status ($p: 0.00$). According to the MNA-SF scores, the mean score was found to be 9.5 ± 2.1 in patients with malnutrition and at risk and 13.1 ± 0.9 in those with normal nutritional status ($p: 0.00$). However, there was a statistical difference between malnourished or at risk of malnutrition and normal nutritional status groups in mean body weight, HGS and MUAC values ($p: 0.04$, $p: 0.01$ and $p: 0.05$, respectively). NLR scores were 2.3 ± 1.00 in patients with malnutrition and at risk and 2.1 ± 0.8 in patients with normal nutritional status, and no statistically significant difference was observed between the groups (Table 2).

Age showed a weak positive correlation with NLR and creatinine ($r: 0.25$, $p: 0.05$, $r: 0.29$ and $p: 0.03$), while a weak negative correlation was found with MNA-SF, albumin and MUAC ($r: -0.35$, $p: 0.01$, $r: -0.28$, $p: 0.05$, $r: -0.26$ and $p: 0.05$). There was a negative weak correlation between NLR and GNRI, body weight and platelet to lymphocyte ratio (PNR) ($r: -0.28$, $p: 0.04$, $r: -0.26$, $p: 0.05$, $r: -0.36$ and $p: 0.01$). While there was a weak positive correlation between MNA-SF and hemoglobin and body weight ($r: 0.27$, $p: 0.04$, $r: 0.27$ and $p: 0.04$), a moderate negative correlation was found with CRP ($r: -0.40$ and $p: 0.01$). In addition, there was a moderate negative correlation between HGS and age and albumin ($r: -0.56$, $p: 0.00$,

Parameters	Malnourished or at risk of malnutrition ^A (n: 23)	Normal nutritional status ^A (n: 37)	<i>p</i> -value ^α
Age (y)	74.1 ± 7.4	68.7 ± 3.9	<i>0.003**</i>
MNA-SF	9.5 ± 2.1	13.1 ± 0.9	<i>0.000**</i>
GNRI	113 ± 14.1	119 ± 11.1	0.06
Albumin (g/dL)	4.1 ± 0.5	4.2 ± 0.35	0.19
Body weight (kg)	73.3 ± 14.6	81.9 ± 16.3	<i>0.038*</i>
BMI (kg/m^2)	29.8 ± 6.6	31.1 ± 5.7	0.45
HGS (kg)	17.3 ± 6.8	22.5 ± 7.8	<i>0.005*</i>
MUAC (cm)	29.6 ± 4.2	31.8 ± 4.3	<i>0.050*</i>
Platelet count (/uL)	257 ± 72.9	254 ± 75.9	0.89
MPV (fl)	10.3 ± 1.4	10.3 ± 0.9	0.93
Hemoglobin (g/dL)	12.3 ± 2.0	13.0 ± 1.7	0.14
Creatinine (mg/dL)	0.9 ± 0.2	0.8 ± 0.3	0.12
WBC (/uL)	7.7 ± 2.5	6.9 ± 2.2	0.18
Neutrophile (cell/mm^3)	4.6 ± 2.1	4.0 ± 1.3	0.20
Lymphocytes (cell/mm^3)	2.0 ± 0.5	2.1 ± 0.8	0.55
CRP	6.2 ± 8.8	5.7 ± 6.9	0.83
NLR	2.3 ± 1.0	2.1 ± 0.8	0.28
LCR	0.9 ± 0.7	0.8 ± 0.8	0.78
PNR	61.5 ± 19.6	68.0 ± 24.9	0.29

Notes: ^αIndependent groups *t*-test; * $p < 0.05$ and ** $p < 0.01$. ^AValues are shown as Mean $\pm$ SD. Nutritional status were classified according to MNA-SF. MNA-SF: Mini Nutritional Assessment-Short Form, GNRI: Geriatric Nutritional Risk Index, BMI: Body Mass Index, HGS: Handgrip Strength, MUAC: Middle Upper Arm Circumference, MPV: Mean Platelet Volume, WBC: White Blood Cell, CRP: C-Reactive Protein, NLR: Neutrophil to Lymphocyte Ratio, LCR: Lymphocyte to C-Reactive Protein Ratio and PNR: Platelet to Lymphocyte Ratio

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Table 2.
Nutritional,
anthropometric and
inflammatory
parameters of the
patients (n: 60)

r: 0.42 and p : 0.00), whereas there was a weak positive correlation with MNA-SF and hemoglobin. (r: 0.36, p : 0.01, r: 0.26 and p : 0.04) (Figure 1).

Table 3 shows the multiple logistic regression analysis of patients with malnourished or at risk of malnutrition. According to the logistic regression analysis, age, HGS, hemoglobin and PNR were found to be statistically significant independent factors for predicting malnutrition or risk of malnutrition in geriatric patients.

Receiver operator characteristic curve analysis showed that the optimum HGS cut-off point for patients with malnourished or at risk of malnutrition was 13.2 with 91.9% sensitivity and 81.0% specificity (95% confidence interval [CI]: 0.58–0.86, area under the curve: 0.72 and p : 0.01) (Figure 2).

Discussion

Malnutrition is more common in geriatric patients and is linked to increased morbidity and mortality, immune dysfunction, frequency of hospitalization, cost of care and poor quality of

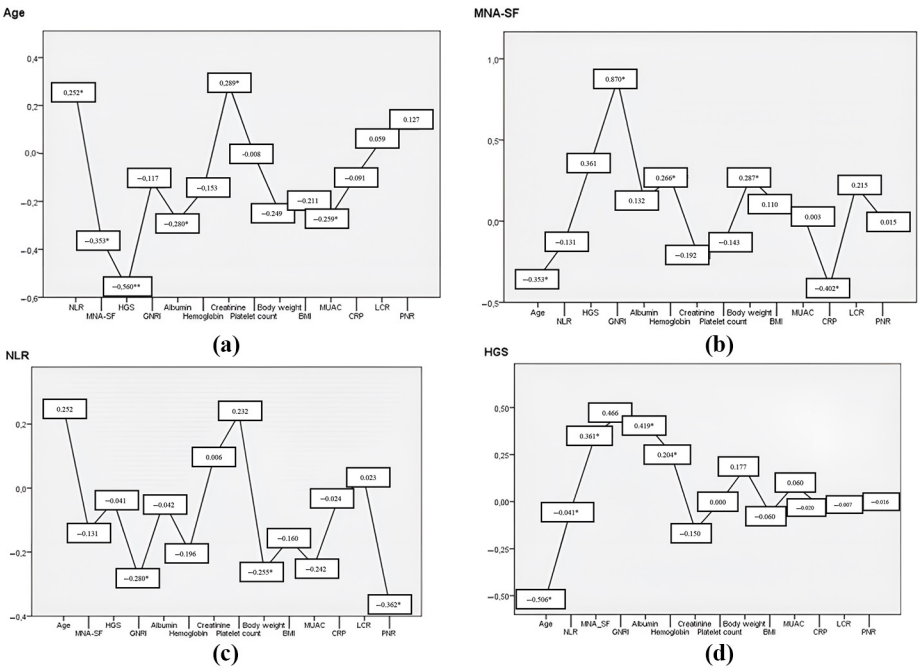


Figure 1. Correlation between age, neutrophil to lymphocyte ratio, mini nutritional assessment short form, handgrip strength and other nutritional, anthropometric and inflammatory parameters

Notes: Age showed a weak positive correlation with NLR and creatinine, and a weak negative correlation with MNA SF, albumin, and MUAC. There was a negative weak correlation between NLR and GNRI, body weight, and PNR, while there was a weak positive correlation between MNASF and hemoglobin and body weight, a moderate negative correlation was found with CRP. In addition, there was a moderate negative correlation between HGS and age, and albumin, whereas there was a weak positive correlation with MNASF and hemoglobin

Source: Created by the authors

life (Bayram *et al.*, 2021; Kaya *et al.*, 2019). Because of these factors, it is critical to monitor the nutritional status of geriatric patients on a regular basis to detect and prevent malnutrition. This study showed that there was no correlation between NLR and MNA-SF, whereas there was a correlation between NLR and GNRI. In addition, HGS was associated with MNA-SF. We found that HGS cut-off value for malnutrition was 13.2 which can identify geriatric patients with malnourished or at risk of malnutrition.

It is well accepted that aging is associated with an increase in the level of systemic inflammation, which plays a prominent role in the emergence of age-related chronic diseases such as cardiovascular diseases, neurodegenerative diseases and several types of cancers (Trtica Majnarić *et al.*, 2021). Chronic activation of innate immune cells is known as a major contributor to increased systemic inflammation and irreversible tissue damage. The systemic inflammation and tissue damage have been specifically associated with increased neutrophil migration into tissue and their prolonged activity in inflamed tissue (Bleve *et al.*, 2022; Yoshida *et al.*, 2022). Various inflammatory markers, especially interleukin-6 (IL-6) and CRP, have been extensively investigated to assess inflammatory status in age-related chronic diseases (Gualtierotti *et al.*, 2016; Mavropoulou *et al.*, 2020). NLR, which can be easily calculated from a CBC, has recently been used as a marker of systemic inflammation. Several studies have indicated that NLR is not only a marker of inflammation but also a prognostic predictor of many diseases such as cardiovascular diseases, cancer and COVID-19 (Corriere *et al.*, 2018; Lian *et al.*, 2020; Zhou *et al.*, 2021). Furthermore, findings from the Rotterdam Study showed that NLR was also a surrogate measure of the aging process in healthy individuals (Fest *et al.*, 2019). Similarly, our findings proved that there is a weak positive correlation between age and NLR in older adults (r : 0.25 and p : 0.05). The NLR may also be affected by multiple factors such as genetic, lifestyle, medicine use and diseases (Buonacera *et al.*, 2022; Dillon *et al.*, 2023). Considering that diseases and medicines that would affect the NLR ratio were not included in the study, it can be said that the increase in age may be the main factor in this relationship.

Older adults are vulnerable to malnutrition for a variety of reasons, including decreased appetite, digestive problems, poor taste and smell, swallowing and chronic diseases (Chang *et al.*, 2021). Our findings have confirmed that there was a negative

	OR	<i>p</i> -value	95% CI
Age	0.84	0.003*	0.75–0.94
NLR	0.71	0.28	0.39–0.32
GNRI	1.09	0.43	0.99–1.19
BMI	1.47	0.26	0.76–2.87
HGS (kg)	1.12	0.019*	1.02–1.23
MUAC (cm)	1.14	0.06	1.00–1.29
CRP	0.99	0.85	0.89–1.10
Hemoglobin	2.19	0.025*	0.01–3.28
PNR	1.05	0.031*	1.01–1.10
LCR	1.05	0.94	0.36–3.01
Albumin	0.22	0.27	0.01–3.28

Notes: * $p < 0.05$, ** $p < 0.001$, GNRI: Geriatric Nutritional Risk Index, BMI: Body Mass Index, HGS: Handgrip Strength, MUAC: Middle Upper Arm Circumference, CRP: C-Reactive Protein, NLR: Neutrophil to Lymphocyte Ratio, LCR: Lymphocyte to C-Reactive Protein Ratio and PNR: Platelet to Lymphocyte Ratio

Source: Created by the authors

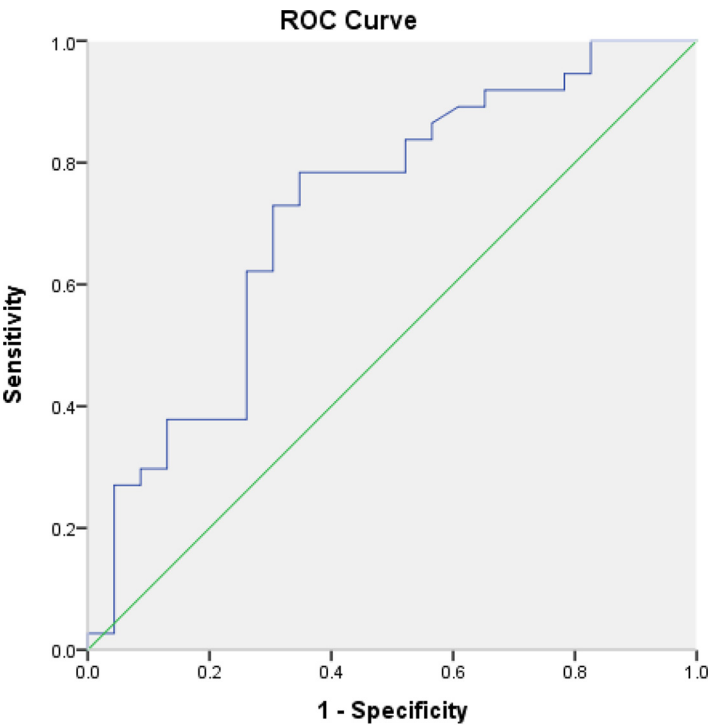
Table 3.
Multiple logistic
regression analysis
of patients with
malnourished or at
risk of malnutrition
according to mini
nutritional
assessment short
form

correlation between age and malnutrition which was defined according to MNA-SF. Generally, MNA and MNA-SF are the most preferable tools to determine the risk of malnutrition in older adults, with high sensitivity and good specificity (Guigoz and Vellas, 2021). In our study, 5.0% of older adults were malnourished, and 33.3% of them were at risk of malnutrition based on the MNA-SF. However, only 1.7% of older adults were at severe/moderate risk of nutrition and 10.0% of low risk of nutrition based on the GNRI. These findings are not a surprise because it has been previously reported that MNA tends to be overdiagnosed in groups at risk of malnutrition (Cereda *et al.*, 2009). Furthermore, serum albumin value is essential for GNRI, unlike MNA-SF. The GNRI is preferable to evaluate the nutritional risk of geriatric patients with serious clinical and complex conditions such as acute injuries, chronic kidney failure, certain malignancies and chronic respiratory failure (Su *et al.*, 2020). According to the present study, older adults who were malnourished or at risk of malnutrition had a lower GNRI score than those in normal nutritional status, but this was not statistically significant. This may be because clinical conditions that could significantly affect serum albumin levels were excluded from this study.

Inflammation has long been recognized as a risk factor for malnutrition (Jensen *et al.*, 2010; Rothenberg, 2021). The aging process, which is accompanied by physical and

Figure 2.

Receiver operating characteristic curve, confidence interval, cut-off point, sensitivity, specificity and predictive value for the best cut-off point of the handgrip strength value to discriminate malnutrition or at risk of malnutrition estimated by mini nutritional assessment short form in geriatric patients. The optimum handgrip strength cut-off point for patients with malnourished or at risk of malnutrition was 13.2 with 91.9% sensitivity and 81.0% specificity (95% confidence interval: 0.58-0.86, area under the curve: 0.72 and p: 0.01)



Source: Created by the authors

psychological changes as well as many comorbidities, has a negative impact on food intake because of increased systemic inflammation and age-related acute and chronic diseases (Pourhassan *et al.*, 2018). CRP has long been used as a biomarker for systemic inflammation, in both acute and chronic diseases (Soeters *et al.*, 2019), and is an independent predictor of inadequate food intake and may increase the risk of malnutrition in acutely ill older hospitalized patients (Pourhassan *et al.*, 2018). However, patients with non-acutely ill older hospitalized patients, and outpatients were included in the present study. Our results found that there was an inverse correlation between CRP and MNA-SF score in non-acutely ill older hospitalized patients and outpatients. As many factors, including aging, affect CRP, the reason for the relationship may not be because of the presence of inflammation alone in these patients.

In addition, it has been suggested that NLR, as a new inflammatory marker, is significantly higher in geriatric patients with malnourished or at risk of malnutrition compared to patients with normal nutritional status (Kaya *et al.*, 2019). However, we observed that NLR was not showed a correlation with MNA-SF but correlated with GNRI. This may be because MNA-SF is an index that defines the risk of malnutrition based on a questionnaire and does not use biological indicators, whereas GNRI is a nutrition-related risk index, which is used as a formula to define the severity of nutritional status-related complications. Furthermore, the ESPEN has suggested a sub-definition of malnutrition without inflammation (Jensen *et al.*, 2010). Therefore, the inflammation-related malnutrition approach alone is unsatisfactory for diagnostic accuracy. Herein, it has been stated that the Global Leadership Initiative on Malnutrition criteria have high diagnostic accuracy because of the etiology-based malnutrition approach and have the potential to be used as the gold standard in clinical practice (Huo *et al.*, 2022). According to the results of the study, it may be more accurate to use GNRI and NLR in the prognosis of the elderly with inflammation-based diseases.

Many studies in the literature have shown that HGS is associated with nutritional status. In a study conducted with outpatients in Indonesia, a weak correlation was found between MNA and HGS (Akbar and Setiati, 2018). Another study conducted in Portugal, MNA and HGS showed a weak relationship. It was observed that the mean HGS was 30.3 ± 9.2 kg in men and 18 ± 5.4 kg in women for evaluating the nutritional status (Mendes *et al.*, 2017). In a study conducted in Turkey, it was found that HGS is more reliable in determining nutritional status with MNA-SF, and the mean HGS was 23.1 ± 9.5 kg for assessing the nutritional status (Kizilarslanoglu *et al.*, 2017). In the present study, a weak correlation was found between HGS and MNA-SF, and the proposed cut-off value of 13.2 kg showed high sensitivity and good specificity to assess the nutritional status. Our study results have confirmed that HGS is a powerful tool for determining nutritional status in geriatric patients.

HGS is a well-accepted indicator of muscle strength and an adopted measure in sarcopenia research (Auyeung *et al.*, 2020; Bhasin *et al.*, 2020). The Sarcopenia Definition and Outcomes Consortium has reported that both low grip strength and low gait speed generally predict adverse health outcomes such as falls, mobility limitation, hip fracture and death. Furthermore, cut-off values of low grip strength for men and women were defined as <35.5 kg and <20.0 kg, respectively (Bhasin *et al.*, 2020). In our study, the mean HGS for men and women were 26.6 ± 2.2 kg and 17.7 ± 0.7 kg, respectively (not shown in tables). Interestingly, the literature has showed that obese individuals have higher maximum muscle strength than non-obese individuals, regardless of age (Bassi-Dibai *et al.*, 2020; Tomlinson *et al.*, 2016). Conversely, our results found that obese older adults have significantly lower HGS compared to non-

obese older adults (not shown in tables). Jeong *et al.* (2018) stated that low HGS in obese elderly may be associated with low muscle mass and high-fat mass, referred to as sarcopenic obesity.

Numerous scientific data have confirmed that nutritional status and sarcopenia are associated with NLR, a marker of systemic inflammation (Siqueira *et al.*, 2021; Öztürk *et al.*, 2018). Recently, a community-based cross-sectional study in Japanese older adults has showed that a higher NLR is associated with poorer physical functions such as lower HGS and slower walking speed (Yoshida *et al.*, 2022). It has also been reported that higher NLR accelerates the age-related decrements in functional connectivity of brain regions involved in the generations of dynamic grip of individuals aged 50 years and older (Dillon *et al.*, 2023). However, most of the current research either lacks any causal relationship between NLR and sarcopenia or has been conducted in certain patients such as cancer. Unlike the literature, we observed that NLR was associated with neither nutritional status nor HGS, which is an important tool in the diagnosis of sarcopenia.

It has long been that malnutrition is a substantial and modifiable risk factor for sarcopenia, which is characterized by age-related low muscle strength and muscle mass. It is well known that malnutrition and sarcopenia often coexist in the elderly population (Verstraeten *et al.*, 2021). Therefore, early recognition of malnutrition, regardless of its etiology, is crucial to reducing the risk of sarcopenia. Remarkably, it was reported that HGS can be included as a reliable tool for assessing nutritional status in clinical practice (Hasheminejad *et al.*, 2016). Similarly, our regression analysis showed that HGS is an independent variable in predicting malnutrition or the risk of malnutrition. As a result, we have concluded that poor nutritional status, which can cause adverse outcomes such as sarcopenia, is related to HGS, but not NLR.

The present study had some limitations. This study design was cross-sectional. Therefore, causal relationships for the associations evaluated here cannot be established. Future longitudinal research should explore the relationship between NLR, HGS and nutritional status in older adults.

Conclusion

In conclusion, the HGS was the most sensitive method to identify malnutrition or risk of malnutrition compared to other anthropometric measurements and biochemical parameters in geriatric non-critically ill patients and outpatients. The proposed cut-off value of 13.2 kg showed high sensitivity and good specificity. In addition, obese older adults had significantly lower HGS compared to non-obese older adults, which may be a result of sarcopenia. However, NLR was not correlated with nutritional status according to MNA-SF, whereas it was correlated with GNRI which defines the severity of nutritional status-related complications. Therefore, it may be more accurate to use GNRI and NLR in the prognosis of the elderly with inflammation-based diseases, not in geriatric non-critically ill patients and outpatients. Our findings suggested that HGS can be used as a tool to determine the nutritional status of geriatric patients. Future research may provide light more insight on this issue.

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