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Original Article
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Correlation between the Nutrition Alert Form (NAF) and the Mini Nutritional Assessment Short-Form (MNA-SF) in Hip Fracture Patients

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ABSTRACT

OBJECTIVE Malnutrition in hip fracture patients can lead to poorer outcomes. The Mini Nutritional Assessment Short-Form (MNA-SF) is a reliable tool for identifying malnutrition risk. This study aimed to assess the correlation between the Nutrition Alert Form (NAF) and MNA-SF, using either body mass index (BMI) or calf circumference (CC) scores, in adult inpatients with hip fractures. Additionally, the study sought to correlate NAF scores with other nutrition parameters and comorbidities.

METHODS A cross-sectional study was conducted at Khon Kaen Hospital, involving hip fracture patients. Spearman's rank correlation coefficient (ρ) was utilized for analysis, with the NAF including patient-directed questions and either BMI (NAF-BMI) or total lymphocyte count (NAF-TLC) when BMI data were unavailable.

RESULTS A total of 152 patients were included in the analysis. The mean age was 68.0±16.7 years, with 31.6% being male. Mean body weight and BMI were 55.1±11.9 kg and 22.2±3.8 kg/m², respectively. MNA-SF (BMI) and MNA-SF (CC) identified 44.1% and 79.6% of patients, respectively, as at-risk for malnutrition, while NAF-BMI and NAF-TLC identified 27.6% and 40.1%, respectively. Moderate correlations were observed between NAF-BMI and MNA-SF (BMI) ($\rho = -0.57$, $p < 0.05$) and MNA-SF (CC) ($\rho = -0.58$, $p < 0.05$). NAF-BMI, NAF-TLC and MNA-SF (CC) were also moderately correlated with the Charlson Comorbidity Index.

CONCLUSIONS NAF-BMI and NAF-TLC are both effective screening tools for identifying malnutrition risk in hospitalized hip fracture patients, demonstrating good correlation with MNA-SF as established nutrition screening tools.

KEYWORDS calf circumference, hand grip strength, hip fracture, nutrition alert form, malnutrition, mini nutritional assessment short-form

INTRODUCTION

Hip fractures pose serious public health challenges and can lead to morbidity and mortality. In Thailand, the prevalence of hip fractures is high, ranging from 151.2 to 238.5 per 100,000 and is steadily increasing annually (1). Several factors contribute to the incidence of hip fractures, including bone health, nutritional status, body weight, age, sex, race, and hormonal abnormalities (2). Low body mass and small body size are linked to increased fracture risk, particularly among elderly Caucasian men and women (3).

In elderly patients, malnutrition not only diminishes physical performance and daily living abilities but also heightens the risk of cognitive impairments, surgical complications, prolonged physiotherapy, and mortality (4). Malnutrition is a modifiable risk factor that should be detected early and treated promptly. Screening for nutrition status is recommended for hospitalized adult patients to identify those at risk of malnutrition. Among nutritional screening tools, the Mini-Nutritional Assessment-short form (MNA-SF) outperforms others such as the Malnutrition Universal Screening Tool (MUST) and the Nutritional Risk Score 2002 (NRS-2002) in predicting various functional outcomes including postoperative acute phase following hip fractures and mortality (5). Approximately 52.6% of hip fracture patients are at-risk for malnutrition, as assessed by MNA-SF (6). Although MNA-SF is primarily used for screening malnutrition in the elderly (7), it can also effectively screen hospitalized young and middle-aged adults, predicting in-hospital mortality (8, 9). In this study, we used the MNA-SF, a well-validated tool designed to screen nutritional status in hip fracture patients, to ensure a standardized approach.

Anthropometric indices, including body mass index (BMI), body weight, and serum albumin, are also used to assess nutrition status. Lower scores on these indices are associated with higher rates of complications and poorer functional recovery (10). However, serum albumin levels are not routinely measured for hip fracture patients upon admission. In Thailand, the Society of Parenteral and Enteral Nutrition of Thailand (SPENT) has endorsed the use of the Nutrition Alert Form (NAF) as a nutrition assessment tool for evaluating the nutrition status of hospitalized patients. NAF exhibits high sensitivity and validity across various clinical settings, can be used by non-nutrition experts, and can be interpreted without knowledge of body weight (11). This study attempted to use NAF as a one-step approach for screening and assessing the nutritional status of hospitalized patients with hip fractures. Validated screening tools are essential for early identification of malnutrition risk, enabling prompt nutritional assessment and intervention, resulting in better cost-effectiveness and improved outcomes (10). The primary objective of this study is to investigate the correlation between MNA-SF and NAF in hospitalized patients with hip fractures. Additionally, we aim to assess the prevalence of at-risk malnutrition and evaluate the correlation between nutrition screening tools, anthropometric parameters (BMI, handgrip strength (HGS), calf circumference (CC), and mid-arm circumference (MAC)), laboratory results (creatinine and total lymphocyte count), and comorbidities using the Charlson Comorbidity Index (CCI) in hospitalized hip fracture patients.

METHODS

Population selection and study design

The present study was a cross-sectional study. All hospitalized individuals with hip fractures were selected through simple random sampling at Khon Kaen Hospital's orthopedic ward between August 2022 and December 2023. The sample size required for correlations, a power of 90.0% and a type 1 error rate (α) of 0.05, allowing for a loss of 10.0%, was 144 subjects (12).

We included 165 patients with hip fractures who met the specified criteria, of whom 13 were excluded, resulting in a final analysis of 152 patients. Inclusion criteria were patients aged 18 years or older, diagnosed with hip fractures based on clinical and radiological findings, capable of answering questions and undergoing testing with anthropometric measurements, and willing to participate in the study. Exclusion criteria were patients with multiple fractures, uncontrolled diabetes (HbA1c ≥ 9.0%), active opportunistic infections (in, e.g., AIDS), end-stage renal disease, congestive heart failure, hormonal deficiencies, hemodynamic instability, malignancies, and pregnancy. The study received approval from the Khon Kaen Hospital Institute Review Board in Human Research, Thailand (approval code KEXP65033), and was conducted in accordance with the Helsinki Declaration of 1975. Prior to participation, all participants provided written informed consent.

We gathered demographic information, including age, sex, current medication use, and medical comorbidities, which were assessed using the CCI. Hip fractures were categorized by anatomic region as either intracapsular or extracapsular fractures (13). Additionally, we reviewed the causes of hip fractures and the types of management employed. The American Society of Anesthesiologists (ASA) physical status classification system was used to categorize patients' physiological status into six types perioperatively, aiding in predicting operative risk (14). Pre-fracture functional status was classified as partially dependent, fully independent, or fully dependent.

All participants underwent nutrition screening using tools such as MNA-SF and NAF on the first day of admission. Anthropometric measurements, including body weight (kg), height (cm), MAC (cm), CC (cm), and HGS (kg), were taken. BMI was calculated using the formula BMI = weight (kg) ÷ height (m^2). Preoperative blood parameters, including BUN (mg/dL), creatinine (mg/dL), and total lymphocyte count (TLC: cells/mm^3), were recorded for analysis.

Anthropometric measurements

Body weight and height

As all patients had hip fractures, a digital weighing scale was used to measure body weight with the patient in a stretcher or wheelchair, and actual body weight was determined by subtracting the weight of the stretcher or wheelchair on the first day of admission. Previous body weight was assessed through history-taking to calculate weight loss. Height was estimated using the half-arm span, from the middle of the sternal notch to the tip of the middle finger, and calculated by doubling the half-arm span (6).

Mid arm circumference (MAC)

MAC was measured in centimeters using a non-stretchable plastic tape. The measurement was taken at the midpoint between the olecranon process and the acromion of the dominant arm while patients were in the supine position, as pain limited their ability to sit (15).

Calf circumference (CC)

CC was measured using a measuring tape at the largest circumference of the calf of the non-fractured leg, with the patient in a supine position and the knee bent at a 90-degree angle. In the MNA-CC, the cutoff point for CC was 31 cm for both genders (16).

Handgrip strength (HGS)

HGS was measured three times using handgrip dynamometry while patients were in the supine position, as pain limited their ability to sit. The highest value obtained using the dominant hand was used in the analysis (15).

Nutrition screening tools

Nutrition Alert From (NAF)

The Society of Parenteral and Enteral Nutrition of Thailand recommends the NAF for assessing the nutritional status of hospitalized patients. Due to its high sensitivity, NAF can be used as a screening tool to stratify nutritional status even by non-nutrition experts. The NAF consists of patient-oriented questions that evaluate weight changes, the quality and quantity of food consumed, gastrointestinal symptoms, the patient's food accessibility, comorbidities, and basic anthropometric measurements like body weight and height, collectively referred to as NAF-BMI. Unlike many tools that rely solely on weight and height, NAF-TLC can be used as an alternative measure when a patient's body weight is unknown. The cutoff scores for NAF are as follows: an A score between 0 and 5 indicates no risk of malnutrition, a B score between 6 and 10 indicates a moderate risk of malnutrition, and a C score greater than 11 indicates a severe risk of malnutrition (11).

Mini Nutritional Assessment Short-Form (MNA-SF)

The MNA-SF is a validated nutrition screening tool used not only in the elderly but also in hospitalized young and middle-aged adults which is capable of predicting outcomes (8, 9). The tool comprises six questions, including assessments of decline in food intake, weight loss over the past three months, mobility, psychological stress or acute disease, neuropsychiatric problems, and BMI or CC when BMI assessment is not possible, indicated by MNA-SF (BMI) and MNA-SF (CC), respectively. The cutoff point for CC related to the risk of malnutrition is 31 cm for both sexes (16). With scores ranging from 0 to 14, the cutoff points are used to classify the risk of malnutrition: scores of 0-7 indicate malnutrition, 8-11 indicate being at risk of malnutrition, and 12-14 indicate a normal nutritional status.

Statistical analysis

All analyses were conducted using IBM SPSS version 16. The normality of the data was assessed using the Shapiro-Wilk test. Quantitative variables are presented as the mean ± standard deviation (SD) or as medians with interquartile ranges (IQR), depending on the normality of the data. Categorical variables are expressed as numbers or percentages and were analyzed using the chi-square test, or Fisher's exact test where appropriate. Continuous variables were categorized based on their cut-off values for malnutrition.

The Spearman rank correlation coefficient (ρ) was used to evaluate the correlation among NAF, MNA-SF, anthropometric parameters, CCI, and laboratory results. The strength of the association was determined based on the absolute value of the Spearman rank correlation coefficients, with ranges of 0.00-0.29, 0.30-0.49, 0.50-0.69, 0.70-0.89, and 0.90-1.00 indicating negligible, low, moderate, high, and very high correlation, respectively (17). MNA-SF is primarily used for screening malnutrition in the elderly (7), but it can also effectively screen hospitalized young and middle-aged adults. Therefore, the subgroup analysis of the correlation between MNA-SF (BMI) and NAF-BMI included individuals aged at least 65 years old (elderly) and adults aged less than 65 years old. Cohen's kappa coefficient was employed to assess the agreement between NAF-BMI and the other screening tools. Statistical significance was considered at a $p < 0.05$, and all tests were two-sided.

RESULTS

Demographics and clinical characteristics

A total of 152 patients who met the inclusion criteria were enrolled for analysis. The participants had a mean age of 68.0±16.7 years, with 31.6% being male. The mean body weight was 55.1± 11.9 kg, and the mean BMI was 22.2±3.8 kg/m^2.

The causes of hip fractures were falling in 77.0% of cases, traffic accidents in 21.1% of cases, and pathological fractures in 1.9% of cases. The diagnosis of hip fractures, confirmed by x-ray imaging, showed that 46.1% were intracapsular fractures and 53.9% were extracapsular fractures. Around 92.1% of patients with hip fractures underwent surgery, while 7.9% were placed on skin traction.

Regarding pre-fracture functional status, 80.2% were fully independent, 0.7% were partially dependent, and 19.1% were either fully dependent or bedridden. The median CCI was 3 (IQR 1.25-4). In terms of the ASA physical classification, 34.2% were classified as healthy, 64.5% as having mild systemic disease, and 1.3% as having severe systemic disease.

For anthropometric assessments, the mean CC for male participants was 31.1±4.8 cm, and for female participants, it was 29.0±3.5 cm. The mean MAC for male participants was 25.8±3.8 cm, and for female participants, it was 24.1±3.3 cm. The mean HGS was 26.0±12.4 kg for male participants and 14.0±9.4 kg for female participants. Anthropometric indices, including CC, MAC, and HGS, differed significantly among different nutritional status groups, with lower levels observed in the malnutrition group at admission.

Upon admission, the median total lymphocyte count was 1,298.84 cells/uL (IQR 919.35-1,752.20). The mean blood urea nitrogen (BUN) level was 17.7 ± 11.1 mg/dL, and the median creatinine level was 0.81 mg/dL (IQR 0.66-1.08). There were no significant differences among the different nutritional statuses. Baseline characteristics categorized by nutritional status are summarized in Table 1.

Prevalence of at-risk malnutrition

The prevalence of at-risk malnutrition/malnutrition, assessed using NAF-BMI and NAF-TLC based on the standard cut-off values of NAF, was 27.6% and 40.1%, respectively. Meanwhile, MNA-SF (BMI) and MNA-SF (CC) showed rates of 44.1% and 79.6%, respectively. The number and percentage of hip fracture patients with at-risk malnutrition are summarized in Tables 2 and 3, classified by MNA-SF (CC), MNA-SF (BMI), NAF-BMI, and NAF-TLC.

Correlation between NAF, MNA-SF (BMI), MNA-SF (CC), Charlson comorbidity index (CCI), anthropometric parameters and laboratory results

The NAF-BMI score has a very high and significant correlation with NAF-TLC, with ρ = 0.91, $p < 0.05$. The NAF-BMI score showed a significant inverse correlation with MNA-SF (BMI) and MNA-SF (CC), with moderate correlations of ρ = -0.57, $p < 0.05$ and ρ = -0.58, $p < 0.05$, respectively. The correlation coefficients for NAF-BMI with other outcomes were as follows: CCI, ρ = 0.64, $p < 0.05$; MAC, ρ = -0.29, $p < 0.05$; HGS, ρ = -0.38, $p < 0.05$; CC, ρ = -0.34, $p < 0.05$; and BMI, ρ = -0.22, $p < 0.05$. The other correlations are shown in Table 4 and Supplementary Figure 1.

Table 1. Baseline characteristics of the study population stratified by MNA-SF (BMI) categories.

Parameters	Overall N=152	MNA-SF (≥ 12) N=85 (55.9%)	MNA-SF (8-11) N=63 (41.5%)	MNA-SF (0-7) N=4 (2.6%)	*p*-value[†]
Age (years)	68.0±16.7	62.3±18.3	74.9±10.9	81.7±6.1	<0.05
Female (%)	104 (68.4)	51 (60.0)	50 (79.4)	3 (75.0)	<0.05
Body weight (kg)	55.1±11.9	61.5±10.4	47.3±8.4	44.3±5.6	<0.05
Body mass index (kg/m^2)	22.2±3.8	24.1±3.1	19.8±3.1	18.8±2.4	<0.05
Calf circumference (cm)					
Male	31.1±4.8	32.8±4.3	27.3±3.5	25.1*	<0.05
Female	29.0±3.5	30.4±3.6	27.8±3.0	25.9±0.7	<0.05
Mid arm circumference (cm)					
Male	25.8±3.8	27.1±3.4	22.6±2.7	22.1*	<0.05
Female	24.1±3.3	25.7±3.2	22.6±2.6	23.2±4.0	<0.05
Hand grip strength (kg)					
Male	26.0±12.4	29.2±12.3	17.7±8.6	23.2*	<0.05
Female	14.0±9.4	14.8±7.6	12.1±4.7	9.4±5.4	0.053
Total lymphocyte count (cells/uL)[‡]	1,298.8 (919.35, 1752.2)	1,315.8 (928, 1,801.8)	1,276.9 (918.2, 1,593.9)	1371.6 (692.5, 2,190.7)	0.75
BUN (mg/dL)	17.7±11.1	16.6±10.2	18.3±11.0	31.5±20.6	0.09
Creatinine (mg/dL)[‡]	0.81 (0.66,1.08)	0.84 (0.68,1.08)	0.79 (0.64,1.00)	1.57 (1.04,2.34)	0.19
Charlson Comorbidity Index[‡]	3.0 (1.25,4.0)	3.0 (1.0,4.0)	4.0 (3.0,4.0)	5.0 (4.5,5.5)	<0.05
Functional status (%)					
Fully independent	122 (80.2)	71 (83.5)	50 (79.4)	1 (25.0)	<0.05
Partial dependent	1 (0.7)	1 (1.2)	0 (0.0)	0 (0.0)	
Fully dependent	29 (19.1)	13 (15.3)	13 (20.6)	3 (75.0)	
ASA physical classification (%)					
Normal healthy	52 (34.2)	34 (40.0)	17 (27.0)	1 (25.0)	0.19
Mild systemic disease	98 (64.5)	51 (60.0)	44 (69.8)	3 (75.0)	
Severe systemic disease	2 (1.3)	0 (0.0)	2 (3.2)	0 (0.0)	
Threat to life	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Not expect to survive	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Cause of hip fracture (%)					
Falling	117 (77.0)	56 (65.9)	57 (90.5)	4 (100.0)	<0.05
Traffic accident	32 (21.1)	27 (31.8)	5 (7.9)	0 (0.0)	
Pathological fracture	3 (1.9)	2 (2.4)	1 (1.6)	0 (0.0)	
Type of hip fracture					
Intracapsular fracture	70 (46.1)	41 (48.2)	27 (42.9)	2 (50.0)	0.37
Extracapsular fracture	82 (53.9)	44 (51.8)	36 (57.1)	2 (50.0)	
Management of hip fracture (%)					
Skin traction	12 (7.9)	8(9.4)	4 (6.3)	0 (0.0)	0.68
Surgery	140 (92.1)	77 (90.6)	59 (93.7)	4 (100.0)	

*Data number = 1

Data are presented as mean ± standard deviation or number (%); [‡]median (interquartile range).

[†]Kruskal-Wallis rank sum test; Fisher's exact test, significant data $p < 0.05$

MNA-SF (BMI) also showed moderate correlations with anthropometric indices including MAC, CC, and BMI, while MNA-SF (CC) had a moderately inverse correlation with CCI. However, NAF-BMI, NAF-TLC, MNA-SF (BMI), and MNA-SF (CC) only showed a negligible correlation with the laboratory results in the present study. The correlations between each nutrition screening tool and other parameters are summarized in Table 4. The agreement evaluated by Cohen's kappa between NAF-BMI and the other tools, including NAF-TLC, MNA-SF (BMI), and MNA-SF (CC), was as follows: 0.60 (95% CI 0.48 to 0.73, $p < 0.05$), 0.41 (95% CI 0.27 to 0.54, $p < 0.05$), and 0.17 (95% CI 0.10 to 0.25), respectively.

A scatter plot illustrating the correlation between NAF-BMI and MNA-SF (BMI) in two age subgroups, at least 65 years and under 65 years, is shown in Figure 1 and Supplement Figure 2. The correlation of NAF-BMI and MNA-SF (BMI) in the

Table 2. Risk of malnutrition among the study population stratified by MNA-SF (BMI) categories.

A Screening Tool	Total (%) (n=152)	MNA-SF (≥ 12) (n=85)	MNA-SF (8-11) (n=63)	MNA-SF (0-7) (n=4)	*p*-value*
NAF-BMI score (%)					< 0.05
A (0-5)	110 (72.4)	77 (90.6)	33 (52.4)	0 (0.0)	
B (6-10)	36 (23.7)	8 (9.4)	27 (42.9)	1 (25.0)	
C (≥11)	6 (3.9)	0 (0.0)	3 (4.8)	3 (75.0)	
NAF-TLC score (%)					< 0.05
A (0-5)	91 (59.9)	66 (77.6)	25 (39.7)	0 (0.0)	
B (6-10)	53 (34.9)	18 (21.2)	34 (54)	1 (25.0)	
C (≥11)	8 (5.2)	1 (1.2)	4 (6.3)	3 (65.0)	

Data are presented as number (%); *Fisher's exact test, significant data $p < 0.05$
BMI, body mass index; MNA-SF, Mini Nutritional Assessment Short-Form; NAF, Nutrition Alert Form; TLC, total lymphocyte count

Table 3. Risk of malnutrition among the study population stratified by MNA-SF (CC) categories.

A Screening Tool	Total (%) (n=152)	MNA-SF (≥ 12) (n=31)	MNA-SF (8-11) (n=111)	MNA-SF (0-7) (n=10)	*p*-value*
NAF-BMI score (%)					< 0.05
A (0-5)	110 (72.4)	31 (100.0)	77 (69.4)	2 (20.0)	
B (6-10)	36 (23.7)	0 (0.0)	32 (28.8)	4 (40.0)	
C (≥11)	6 (3.9)	0(0.0)	2 (1.8)	4 (40.0)	
NAF-TLC score (%)					< 0.05
A (0-5)	91 (59.9)	29 (93.5)	61 (55.0)	1 (10.0)	
B (6-10)	53 (34.9)	2 (6.5)	47 (42.3)	4 (40.0)	
C (≥11)	8 (5.2)	0 (0.0)	3 (2.7)	5 (50.0)	

Data are presented as number (%); *Fisher's exact test, significant data $p < 0.05$
BMI, body mass index; MNA-SF, Mini Nutritional Assessment Short-Form; NAF, Nutrition Alert Form; TLC, total lymphocyte count

Table 4. Correlation between NAF-BMI, NAF-TLC, MNA-SF (BMI), MNA-SF (CC), Charlson Comorbidity Index (CCI), and anthropometric parameters.

Parameters	NAF-BMI score		NAF-TLC score		MNA-SF (BMI)		MNA-SF (CC)	
	ρ†	*p*-value	ρ†	*p*-value	ρ†	*p*-value	ρ†	*p*-value*
NAF-BMI			0.91	<0.05	-0.57	<0.05	-0.58	<0.05
CCI	0.64	<0.05	0.66	<0.05	-0.36	<0.05	-0.50	<0.05
MAC (cm)	-0.29	<0.05	-0.21	<0.05	0.62	<0.05	0.30	<0.05
HGS (kg)	-0.38	<0.05	-0.36	<0.05	0.38	<0.05	0.47	<0.05
CC (cm)	-0.34	<0.05	-0.28	<0.05	0.57	<0.05	0.49	<0.05
BMI (kg/m^2)	-0.22	<0.05	-0.15	>0.05	0.66	<0.05	0.13	>0.05
TLC (cells/mm^2)	-0.09	>0.05	-0.43	<0.05	0.05	>0.05	0.06	>0.05
BUN (mg/dL)	0.17	<0.05	0.18	<0.05	-0.12	>0.05	-0.22	<0.05
Creatinine (mg/dL)	0.19	<0.05	0.20	<0.05	0.05	>0.05	-0.12	>0.05

†Spearman's Rank Order Correlation (ρ), correlation is significant at the 0.05 level (2-tailed).
BMI, body mass index; BUN, blood urea nitrogen; CC, calf circumference; HGS, hand grip strength; MAC, mid-arm circumference; MNA-SF, Mini Nutritional Assessment Short-Form; NAF, Nutrition Alert Form; TLC, total lymphocyte count

age group ≥ 65 years old showed a moderate correlation of $\rho = -0.55$, $p < 0.05$, while the correlation was low in the age group < 65 years old, with $\rho = -0.40$, $p < 0.05$ (Supplementary Table 1).

DISCUSSION

In this study, we found a moderate correlation between NAF-BMI and MNA-SF (BMI) in hospitalized hip fracture patients. The prevalence of

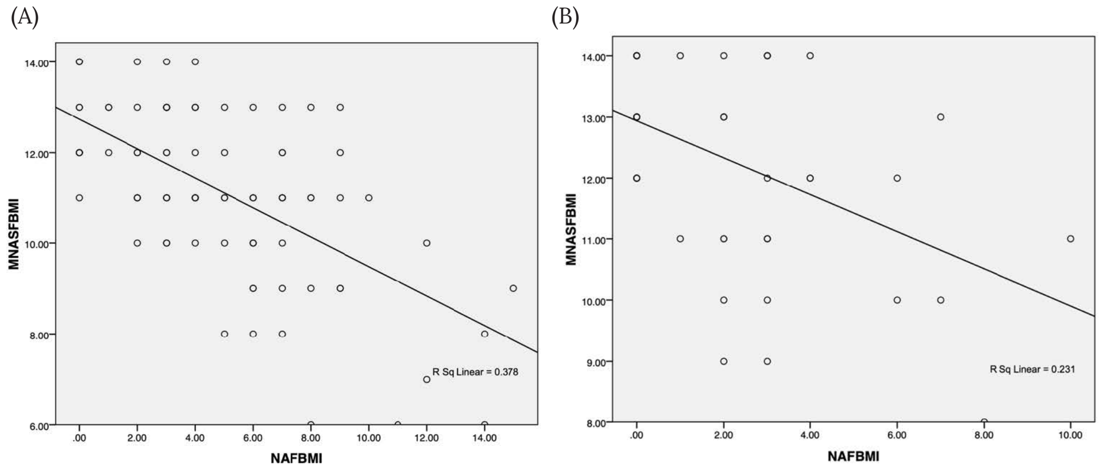

Figure 1. Scatter plot illustrating the correlation between NAF-BMI and MNA-SF (BMI) in (A) participants aged ≥ 65 years and (B) participants aged < 65 years

at-risk malnutrition and malnutrition, as determined by NAF-BMI and NAF-TLC, was 27.6% and 40.1%, respectively, while MNA-SF (BMI) and MNA-SF (CC) showed rates of 44.1% and 79.6%, respectively. This study is the first to assess the correlation between NAF and MNA-SF in hospitalized patients with hip fracture using both simple and validated nutrition screening tools.

Insufficient energy and protein intake are prevalent both before admission as preexisting malnutrition and after hip surgery, exacerbated by the catabolic response to injury and surgery (18). Consequently, malnutrition and sarcopenia can hinder rehabilitation, prolong hospital stays, and worsen clinical outcomes (6). Overall, malnutrition in hip fracture patients can lead to increased morbidity, mortality, and healthcare costs (19). The prevalence of malnutrition ranges from 4% to 39.4% according to various nutritional assessment tools (20), with half of hip fracture patients at risk of malnutrition as assessed by MNA-SF (18). While the European Society for Clinical Nutrition and Metabolism (ESPEN) recommends postoperative oral nutritional supplementation (ONS) for geriatric hip fracture patients without determining their nutritional status, hospitalized patients with preexisting malnutrition have been shown to benefit from ONS, which has also been proven to be cost-effective (21). Despite SPENT recommending NAF as an assessment tool, NAF can also be utilized as a one-step approach to screen for and assess malnutrition risk due to its high sensitivity, around 80.0-97.0% and high specificity, around 75.0-91.3% (22-24), and validity in various clinical settings to evaluate the nutrition status of hospitalized patients within 48 hours of admission. In hospitals with limited resources, NAF can be used to prioritize patients at preexisting risk of malnutrition and identify malnourished patients in one step, allowing for urgent nutrition interventions. This approach can also likely lead to time saving.

A previous study found that the NAF-BMI exhibited a moderate agreement with the full form of the MNA, with Cohen's kappa coefficient of 0.56 (22). As a one-step approach for screening and assessing nutrition status, our study also demonstrated a moderate correlation and a moderate agreement between NAF-BMI and MNA-SF (BMI). There is also a moderate correlation and slight agreement between NAF-BMI and MNA-SF (CC). A previous study validated both forms of MNA-SF (BMI) and MNA-SF (CC) for assessing the nutritional status of older adults. However, the sensitivity of MNA-SF (BMI) and MNA-SF (CC) was 72.0% and 92.0%, respectively, while the specificity was 95.6% and 73.8%, respectively. Thus, the prevalence of malnutrition assessed by MNA-SF (BMI) was 16.5% in free-living elderly, similar to the MNA full form, whereas MNA-SF (CC) overestimated the prevalence at 38.0% (25). Similarly, our study identified 44.1% and 79.6% of patients as at risk for malnutrition and malnourishment, respectively, using MNA-SF (BMI) and MNA-SF (CC). Furthermore, our study recommended using MNA-SF (BMI) as the screening tool due to the risk misclassification of MNA-SF (CC) (26). The cut-off point for CC is population-specific and depends on factors such as sex, age, BMI, and country. It should be validated against a reliable tool, such as the skeletal muscle mass index. For the elderly Asian population, the cut-off ranges from 23.6 to 34.0 cm in men and 23.6 to 33.0 cm in women (27, 28). Furthermore, there are still scant studies examining a cut-off value for young and healthy adult populations (29). Therefore, the overdiagnosis of at-risk malnutrition using the MNA-SF (CC) may be due to the high cut-off value of CC in the test. However, another study with a larger sample size showed a similar prevalence of at-risk malnutrition/malnutrition, evaluated by MNA-SF (BMI) and MNA-SF (CC), at 27.4% and 27.7% in free-living elderly, respectively (30). Despite the MNA-SF being a validated nutritional screening tool for both elderly and middle-aged adults (8, 9), our study highlighted a stronger correlation between NAF and MNA-SF in the elderly group. Therefore, both MNA-SFs can be considered rapid, easy, and reliable tools for identifying the risk of malnutrition, especially in the elderly.

In our study, we observed a higher CCI among hip fracture patients classified as at-risk malnourished and malnourished when compared to those with normal nutrition status as classified by the MNA-SF. The CCI score is commonly employed to predict mortality in hip fracture patients (31). There exists a moderate correlation between CCI and MNA-SF (CC). Among patients with hip fractures, the ASA class and a high CCI score, particularly ≥ 4, can predict short-term and long-term mortality (32, 33). Previous studies have also shown that patients identified as being at risk of malnutrition or malnourished according to the MNA-SF tend to have a higher CCI (34). Certain comorbidities incorporated into the CCI, such as chronic obstructive pulmonary disease and chronic kidney disease, are known to be linked with systemic inflammation. This association often leads to heightened metabolic demands and anorexia, which in turn can culminate in the development of sarcopenia and malnutrition. These underlying mechanisms may elucidate the elevated risk of malnutrition observed in hip fracture patients with higher CCI scores. Consistent with our findings, previous research has demonstrated an inverse association between MNA-SF and HGS with CCI score (34). While nutrition status may be confounded by higher comorbidities, the combination of malnutrition and a high CCI may lead to additional poorer outcomes. The compounded impact of malnutrition and diminished HGS has been shown to escalate the risk of all-cause mortality (35).

Several noninvasive anthropometric indices, such as CC and MAC, reflect muscle mass and nutritional status, while HGS serves as an indicator of low muscle strength and is a component of sarcopenia diagnosis. These indices are particularly relevant for assessing the prognosis and functional outcomes of hip fractures, especially in the elderly (15, 16, 36). In adults under 60 years old with hip fractures, low levels of physical activity have been shown to be associated with low HGS and higher ASA grade, potentially leading to higher mortality rates (37). MAC is used to represent muscle mass and subcutaneous fat, especially when the edematous state commonly affects CC. Both MAC and CC demonstrate similar diagnostic performance in diagnosing sarcopenia (15). Our study also revealed a significant correlation between anthropometric indices, including HGS, CC, and MAC, and nutrition status as assessed by both NAF and MNA-SF, consistent with previous studies which have shown varying degrees of correlation (38). However, the measurement technique for hand grip strength and the cutoff value in patients with hip fractures are limited by the supine position.

In a systematic review and meta-analysis, low serum albumin levels, malnutrition, and low TLC were identified as predictors of poorer outcomes following hip fracture surgery (39). Currently, serum visceral proteins such as albumin and prealbumin are utilized to forecast surgical outcomes and mortality rates (40). However, there is no single laboratory marker that comprehensively represents nutritional status. Our study did not observe a significant correlation between laboratory results and nutrition status.

This study represents a pioneering effort in assessing the prevalence of at-risk malnutrition and malnutrition among patients with hip fractures through the utilization of the NAF. Additionally, it undertakes a comparative analysis of NAF with various screening tools, including the MNA-SF, anthropometric indices, and laboratory markers, within the context of hospitalized hip fracture patients. Furthermore, this study seeks to extend the application of the MNA-SF to screen for malnutrition in young adults, a demographic for which scant studies have employed the MNA-SF for this purpose (8, 9).

The present study is subject to several limitations that warrant acknowledgment. Firstly, its cross-sectional design precludes the establishment of a temporal relationship between nutrition status and clinical outcomes. Secondly, there remains uncertainty regarding the efficacy of nutrition screenings for detecting malnutrition and administering early nutrition interventions compared to providing oral nutrition supplements to all patients undergoing hip fracture surgery, as recommended by current guidelines. Lastly, we observed variability in malnutrition prevalence when altering certain factors within the same screening tools, despite significant correlations among these tools. Future studies should prioritize investigating outcomes and cost-effectiveness following nutrition interventions among either hip fracture patients with pre-existing malnutrition or without malnutrition.

CONCLUSIONS

Our findings suggest that NAF is an effective screening tool for identifying malnutrition risk in hip fracture patients, correlating well with MNA-SF as established nutrition screening tools. NAF-TLC and MNA-SF (CC) can serve as simple tools to screen for malnutrition risk in hospitalized hip fracture patients, especially when BMI cannot be accessed. The varying prevalence rates of at-risk malnutrition need further evaluation, and prompt nutrition intervention in those malnourished cases should be assessed in further studies.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

ADDITIONAL INFORMATION:

C.U., T.P.: conceptualization, methodology, software, writing – review & editing; C.U., N.J.: data curation, writing-original draft preparation; T.P.: visualization, investigation; K.S, K.C.: supervision; N.J.: software, validation

The data used in this study are not publicly available due to participant privacy but are available from the corresponding author upon reasonable request.

Supplementary materials

The following supporting information can be downloaded at: Supplementary appendix

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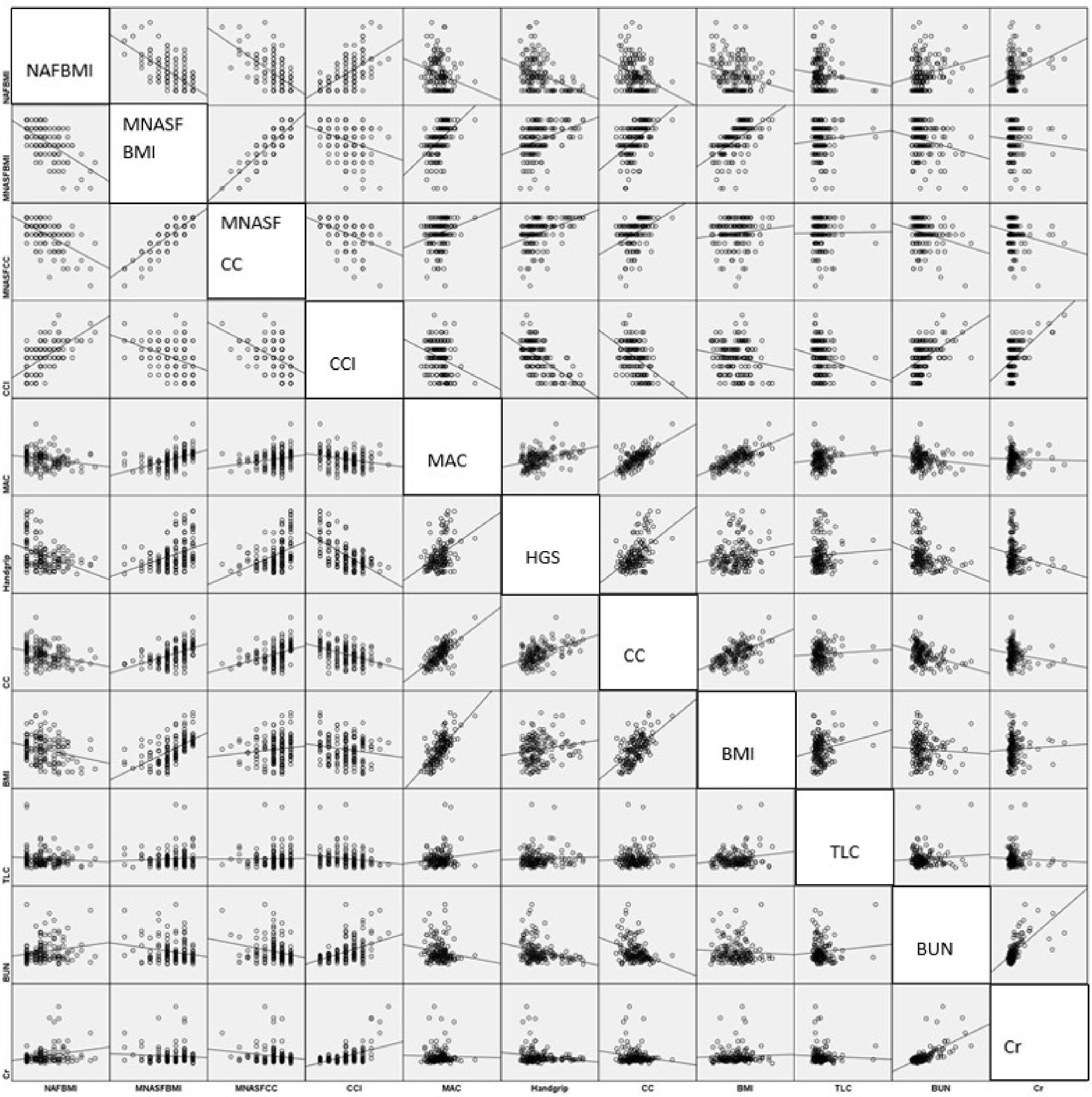
Supplementary Figure 1: Correlation between NAF-BMI, MNA-SF (BMI), MNA-SF (CC), Charlson Comorbidity Index, anthropometric parameters, and laboratory results.



Supplement Table 1: Correlation between NAF, MNA-SF (BMI), MNA-SF (CC), Charlson comorbidity index (CCI) in age group ≥65 years, < 65 years

Parameters	NAF-BMI score		MNA-SF (BMI)		MNA-SF (CC)	
Age group	ρ †	*p*-value	ρ †	*p*-value	ρ †	*p*-value
NAF-BMI score in age group ≥65 years			-0.55**	< 0.05	-0.48**	< 0.05
NAF-BMI score in age group <65 years			-0.40**	< 0.05	-0.47**	< 0.05
CCI in age group ≥65 years	0.47**	< 0.05	-0.08	0.47	-0.177	0.08
CCI in age group <65 years	0.61**	< 0.05	-0.42**	< 0.05	-0.41**	< 0.05

†Spearman's Rank Order Correlation(ρ)

**Correlation is significant at the 0.01 level (2-tailed).

Supplement Figure 2: Scatter plot showed the correlation NAF-BMI, MNA-SF and CCI A) age group ≥65 years B) age group < 65 years.