


# Correlation Between Mini Nutritional Assessment and Anthropometric Measurements Among Community-Dwelling Elderly Individuals in Rural Southern Thailand

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**Purpose:** The Mini Nutritional Assessment (MNA) can be applied to assess nutrition status among community-dwelling elderly individuals by health care professionals. This study aimed to evaluate the correlation of MNA score and anthropometric measurements, gait speed, and handgrip strength among elderly community members. The secondary outcome was to compare the performance of the MNA-SF with the full MNA.

**Materials and Methods:** The study was a cross-sectional study with 176 elderly individuals aged  $\geq 60$  years living in rural southern Thailand. The MNA-SF and full MNA scores were obtained by using the standard form in the Thai version of the MNA. We collected anthropometric measurements, gait speed, handgrip strength, and MNA data.

**Results:** There was a significant positive correlation between body weight, BMI, waist circumference, hip circumference, waist-to-height ratio, waist-to-hip ratio, mid-upper arm circumference, calf circumference, triceps skinfold thickness, handgrip strength and full MNA total score using the partial correlation coefficient after controlling for age and sex. The MNA-SF had sensitivity of 78.79%, specificity of 81.82%, PPV of 50%, NPV of 94.35%, LR+ of 4.33, LR- of 0.26, accuracy of 81.25% and AUC 0.901 when using the full MNA as a reference standard.

**Conclusion:** The MNA correlated with many anthropometric measurements. The MNA-SF had a high specificity, NPV and accuracy of more than 80% when compared with the full MNA.

**Keywords:** mini nutritional assessment, malnutrition, elderly, community, anthropometric measurement

## Introduction

Malnutrition is an important problem in the elderly population. Nutrition status affects the process of aging and health in elderly people.<sup>1</sup> Body composition changes during the aging process, and this also influences nutritional status. There is a progressive decrease in lean body mass and an increase in body fat.<sup>1-3</sup> Malnutrition and unintentional weight loss contribute to progressive declines in health, impaired muscle and cognitive function, reduced physical activities, decreased immune function and increased mortality rates.<sup>1,4</sup>

The Mini Nutritional Assessment (MNA) is a screening and assessment tool for nutritional status. It has a reliable scale and clearly defined thresholds.<sup>5</sup> The MNA has been used in primary care by health care professionals to assess nutrition status

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among community-dwelling elderly individuals because it is available in the community setting and easy to use. Furthermore, it can be used in in-patient department (IPD) and out-patient department (OPD) clinical settings.<sup>5–7</sup> The MNA has been recommended by many national and international clinical and scientific organizations. It can be used worldwide by a variety of health professionals, such as physicians, dietitians, nurses, or research assistants.<sup>8</sup> The MNA is a noninvasive, simple, well-validated screening tool for malnutrition in elderly individuals in the community, and is recommended for early detection of risk of malnutrition.<sup>9</sup>

There are two forms of the MNA for assessing nutritional status: the first is the full-form Mini Nutritional Assessment (full MNA), and the second is the short-form Mini Nutritional Assessment (short MNA) or MNA-SF. A limitation of the full screening tool is the large number of items and the length of time required to administer the full MNA, particularly in the primary care and community settings. Since the full MNA is long, has multiple questions and requires much time to complete, the MNA-SF was created in response, particularly for settings where time is limited.<sup>5,6,8,10</sup> A previous study showed that the MNA-SF has validity and can be applied in clinical practice and used to assess nutritional status in elderly individuals.<sup>6</sup> The full MNA contains 18 items to evaluate nutritional risk that were especially developed for elderly individuals and remains the gold standard for ambulatory elderly individuals.<sup>11</sup>

The MNA-SF was developed by selecting 6 optimal items from the full MNA to evaluate nutritional risk. The MNA-SF was revised to assess nutritional status with a standardized 6 items, and cut-points were developed to classify outcomes among elderly individuals into three groups, the normal nutritional status group, the at risk of malnutrition group and the malnourished group, the same groups as in the full MNA but using fewer items. Examples of items were reviewed in previous studies, and they are shown in the methods section and at [www.mna-elderly.com](http://www.mna-elderly.com).<sup>5,6,8,10</sup> Furthermore, previous studies demonstrated that anthropometric measurements, such as body mass index (BMI), calf circumference, triceps skinfold thickness and mid-upper arm circumference can be co-evaluated with MNA for assessing nutritional risk.<sup>6,12</sup>

Anthropometric measurement is an essential feature of geriatric nutritional evaluation because some geriatric syndromes can be detected with anthropometry, such as frailty, malnutrition and sarcopenia.<sup>13,14</sup> Anthropometry in elderly individuals included body weight, height, BMI,

waist circumference, hip circumference, waist-to-height, waist-to-hip ratio, triceps skinfold thickness, and mid-upper arm circumference.<sup>15,16</sup> These measurements can be used to determine malnutrition status and the prognosis of chronic and acute diseases and to assess risk factors for frailty in the elderly.<sup>17,18</sup>

In Thailand, the elderly population is the second-highest among the Association of Southeast Asian Nations (ASEAN) countries. Over the next 20 years, the proportion of elderly individuals in the population of Thailand is expected to increase.<sup>19</sup> The nutritional status of the elderly population, as they represent a larger proportion of the total population, is salient to social welfare because malnutrition can cause impaired functional status and poor quality of life. There is no previous study on the validation of the MNA-SF compared with the full MNA in southern Thailand or on the correlation between the two MNA types and anthropometric assessments in southern Thailand. This study aimed to evaluate the correlation of the MNA and anthropometric measurements among community-dwelling elderly individuals in rural southern Thailand. The secondary outcome was to compare the performance of the MNA-SF with the full MNA in this population.

## Materials and Methods

### Study Design, Setting and Sample Size

This cross-sectional study was carried out in Pak Phanang District, Nakhon Si Thammarat, Thailand, a province in southern Thailand, from 30 April 2020 to 31 July 2020. Per sample size calculations, at least 168 patients were required for our study. Overall, 176 participants, 75 men and 101 women, aged  $\geq 60$  years, living in rural southern Thailand and who could communicate and answer the questionnaire voluntarily participated in this research after giving informed consent. The participants were selected by using simple random sampling from the communities. The exclusion criteria were participants who lived in a nursing home, were bed ridden, or who were admitted to the hospital. The sample size (N) was calculated by using the single proportion population formula:

$$N = Z^2 p(1 - p) / d^2$$

where  $p$  = prevalence of malnutrition from a previous study,  $d$  = margin of error, and  $Z$  = statistic for a level of confidence, which equals 1.96 for a 95% CI. The sample size was calculated based on the prevalence of malnutrition found in a relevant previous study, 12.5%,<sup>20</sup> with

a precision of 0.05 and a confidence level of 95%. This study was approved by the Ethics Committee on Human Rights Related to Research Involving Human Subjects, Walailak University, Thailand (WUEC-20-112-01).

## Data on Characteristics of the Elderly Participants

Demographic data were collected, including age, sex, marital status, religion, education, underlying disease, current working status, living alone status, history of hospital admission in the last year, history of falling in the last year, smoking, alcohol consumption and exercise. The validity of all questionnaires was evaluated by three experts in the field of internal medicine. The information was obtained through face-to-face interviews by community health volunteers at the patient's home with COVID-19 precaution techniques, such as use of alcohol-based cleaners, hand washing and a simple face mask.<sup>21</sup> All thirteen community health volunteers received a 1-hour orientation from the physician about the questionnaires before administering the survey. All demographic data were recorded by community health volunteers using a Google form.

The MNA-SF, full MNA, gait-speed test, handgrip strength and anthropometric measurements were obtained in the next step after completing demographic data. The researcher met with the participants for these assessments 1–2 weeks after recording demographic data. Figure 1 illustrates a summary of the step of study protocol. First, the demographic data in the Google form were rechecked by the physician in internal medicine before going to the next step. Second, systolic blood pressure and diastolic blood pressure were measured by an autonomic sphygmomanometer with an appropriate arm cuff at heart level after participants had been sitting quietly for 5–15 minutes by community health volunteers and using the standard method.<sup>22,23</sup> Third, anthropometric measurements, such as body weight, height, BMI, waist circumference, hip circumference, waist-to-hip ratio, waist-to-height ratio, mid-upper arm circumference, calf circumferences and triceps skinfold thickness were evaluated by community health volunteers. All thirteen community health volunteers were trained by the physician in all anthropometric measurements, geriatric assessment and data collection. The anthropometric measurements were divided into three stations. The first station is body weight, height and BMI. The second station is waist circumference, hip

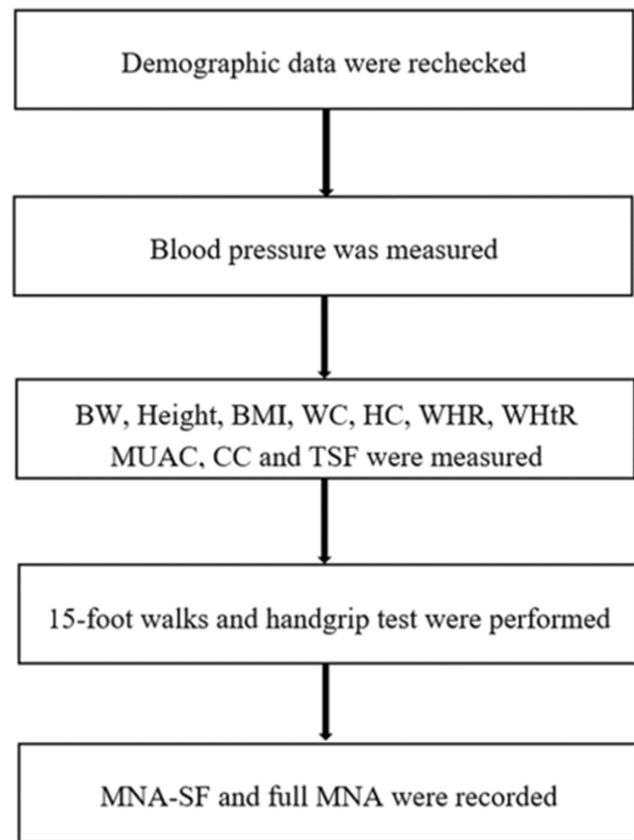


Figure 1 Step of study protocol.

circumference, waist-to-hip ratio and waist-to-height ratio. The third station is mid-upper arm circumference, calf circumferences and triceps skinfold thickness. Fourth, geriatric assessments were performed into two steps, such as assessing for slow gait by 15-foot walks and the strength of hand muscles by handgrip test. Each step in the third and the fourth process was run by two community health volunteers to avoid observer bias. The other three volunteers managed the data collection and arranged the participant's approach to each station randomly. Finally, the MNA-SF and full MNA were administered by the physician in internal medicine. The MNA-SF consists of the same set of items as the first 6 items of the full MNA; when the physician had obtained responses for the first 6 items, the physician then continued and obtained the remaining items (7–18) of the full MNA.<sup>5,6,8,10</sup> The malnutrition risk category of participants was classified after completing the MNA-SF and full MNA data records.

## Anthropometric Measurements

Body weight and height were measured with the participants in a standing position and barefoot using an electronic

digital scale and a stadiometer (NAGATA BW-2232MH, Taiwan), respectively. Body weight was obtained to the nearest 0.1 kg, and height was obtained to the nearest 0.1 cm. BMI was calculated as body weight (kg) divided by height squared ( $\text{m}^2$ ).<sup>24</sup> The Regional Office for the Western Pacific (WPRO) definition classifies underweight as BMI  $<18.5 \text{ kg/m}^2$ , normal range as BMI  $18.5\text{--}22.9 \text{ kg/m}^2$ , overweight as BMI  $23\text{--}24.9 \text{ kg/m}^2$ , class I obesity as BMI  $25.0\text{--}29.9 \text{ kg/m}^2$  and class II obesity as BMI  $\geq 30 \text{ kg/m}^2$ .<sup>25,26</sup>

Waist circumference (WC) was measured with inelastic tape at the midpoint between the lower rib cage and iliac crest in the horizontal plane around the body in the standing position with a relaxed abdomen and both arms resting at the sides. The WC was obtained to the nearest 0.1 cm at the end of a normal exhalation.<sup>27,28</sup> Hip circumference (HC) was obtained at the widest point between the hips and buttocks. The WC and HC were obtained twice times and using the averaged value for the results. The waist-to-height ratio (WHtR) was calculated by dividing the WC by the height. The WHtR  $\geq 0.5$  was defined as increased risk of cardiovascular disease.<sup>29,30</sup> The waist-to-hip circumference (WHR) was calculated by dividing the WC by the HC. An increased WC was defined as  $\geq 90 \text{ cm}$  in males and  $\geq 80 \text{ cm}$  in females. An increased WHR was defined as  $\geq 0.9$  in males and  $\geq 0.85$  in females.<sup>31</sup>

Mid-upper arm circumference measurement (MUAC) was measured in the left arm at the midpoint of the acromion process and olecranon process as the elbow flexed 90 degrees in the palm facing up position.<sup>32</sup> Calf circumference (CC) was measured as the maximum horizontal distance around the left calf as the participants stood upright.<sup>33</sup> MUAC and CC were measured with a measuring tape and recorded to the nearest 0.1 cm. The MUAC and CC were obtained twice times and using the averaged value for the results. MUAC and CC were interpreted by sex and age and into quantitative tertiles.<sup>32,33</sup>

Triceps skin fold (TSF) thickness was measured at the midpoint of the left arm (between the acromial process and the olecranon) with the arm freely stretched along the body. A fold of skin was then pinched with the fingers for 3–4 seconds, and a scientific caliper (Lange skin fold caliper, California) was applied.<sup>34</sup> TSF thickness was measured with a measuring tape and recorded to the nearest 0.1 mm. The TSF was obtained twice times and using the averaged value for the results. TSF thickness was interpreted by sex- and age-specific normative reference standards.<sup>35</sup>

## Gait Speed Test

The gait speed test is used to evaluate the slowness of elderly individuals. The participants walked on the floor from the starting point to the finishing point in a straight line, with a total distance from start to finish of 15 feet. The total time spent walking 15 feet was recorded to the nearest 0.1 minute by community health volunteers.<sup>36,37</sup> The community health volunteers were trained by a physician before the test. The interpretation of slow gait depended on sex and height.<sup>38</sup>

## Handgrip Strength

Handgrip strength is used to evaluate weakness in elderly individuals. The participants were tested in the sitting position with dominant hand by using a digital handgrip strength dynamometer (T.K.K. grip 5401, Japan). Handgrip strength was recorded 3 times to the nearest 0.1 kg by community health volunteers. The community health volunteers were trained by a physician before the test.<sup>39–41</sup> The mean handgrip strength was calculated in the data analysis. The interpretation of handgrip strength depended on sex and BMI.<sup>38</sup>

## Short MNA or MNA-SF

The short MNA or MNA-SF used the standard form from previous studies and the Thai version at [www.mna-elderly.com](http://www.mna-elderly.com). The MNA-SF is the common tool for screening of nutritional status in the elderly.<sup>10,42</sup> The participants were classified in the normal nutritional status group if the MNA-SF total score was 12–14, at risk of malnutrition group if the MNA-SF total score was 8–11 and group if the malnourished group the MNA-SF total score was 0–7.<sup>5,6,8,10</sup> The reliability of the questionnaire was pretested with thirty individuals in a nonstudy sample of elderly people who lived in a rural area outside the study area, and Cronbach's alpha coefficient for the questionnaire was calculated to be 0.714.

## Full MNA

The full MNA also used the standard form from previous studies and the Thai version at [www.mna-elderly.com](http://www.mna-elderly.com). The participants were classified in the normal nutritional status group if the full MNA total score was 24–30, at risk of malnutrition group if the full MNA total score was 17–23.5 and the malnourished group if the full MNA total score was  $<17$ .<sup>5,6,8,10</sup> The reliability of the questionnaire was pretested with thirty individuals in a nonstudy sample of elderly people who lived in a rural area outside the study area,



and Cronbach's alpha coefficient for the questionnaire was calculated to be 0.721.

## Data Analysis

Data were rechecked and cleaned before analysis. Statistical analysis was performed using the R environment version 4.0.5 for statistical computing. Quantitative variables are described as the mean  $\pm$  standard deviation. Categorical variables are expressed as percentages and frequencies. Data were classified before data analysis into two groups: participants who had an abnormal nutritional status (those who had at risk of malnutrition or malnourished status by using full MNA) and participants who had a normal nutritional in Tables 1 and 2. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), negative likelihood ratio (LR-), and accuracy of the MNA-SF compared with the full MNA as a reference standard were analyzed as a percentage with 95% CI. The correlations between anthropometric variables, 15-foot walk, handgrip strength and MNA total score were analyzed by score using the partial correlation coefficient after controlling for age and sex. The area under the curve (AUC), cut-off, sensitivity and specificity of functional assessments, anthropometric measurements and MNA-SF score to predict abnormal nutritional status were analyzed and created graphs of the ROC curve by using MedCalc version 20. Classification of AUC: acceptable 0.7–0.8, excellent 0.8–0.9 and outstanding > 0.9.<sup>43</sup> The results were considered significant when the *P* value was <0.05.

## Results

### Characteristics of the Elderly Participants

A total of 176 participants, 75 men and 101 women, between 60 and 87 years of age were included in this study. The mean age of the participants was 70.18 (standard deviation 6.72) years. Characteristics of elderly participants are presented in Table 3. Most participants were between the ages of 60 and 69 years (53.41%). Most participants were married (72.16%). Buddhism (96.60%) was the most common religion. Most participants' educational attainment was primary school (44.89%). The most common underlying diseases in this study were hypertension (47.16%), hyperlipidemia (31.25%), diabetes mellitus (20.45%), osteoarthritis of the knee (17.61%), dyspepsia or GERD (7.39%), heart disease (7.39%), renal disease (5.68%), gout (2.84%), COPD or asthma (2.27%) and allergic rhinitis (2.27%). Most community-dwelling elderly individuals were classified as having a normal nutritional status, ie, very little risk of malnutrition. The prevalence of a malnourished group was 2.84% when using the MNA-SF and 2.27% when using the full MNA. The prevalence of at risk of malnutrition was 26.70% when using the MNA-SF and 16.48% when using the full MNA.

### Outcome of the Full Mini Nutritional Assessment (18 Items)

The outcomes of the full MNA administered to elderly individuals are presented in Table 4. The percentage of severe decrease in food intake was 2.84%. The percentage

**Table 1** The AUC, Cut-off, Sensitivity and Specificity of Functional Assessments, Anthropometric Measurements and MNA-SF Score to Predict Abnormal Nutritional Status (n=176)

Variables	AUC	95% CI	P value	Cut-off	Sensitivity (%)	Specificity (%)
Body weight (kg)	0.684	0.609–0.751	0.001*	$\leq 57.40$	69.7	63.6
BMI (kg/m <sup>2</sup> )	0.625	0.549–0.697	0.037*	$\leq 21.84$	51.5	75.5
Waist circumference (cm)	0.685	0.611–0.753	0.001*	$\leq 83.50$	75.8	62.9
Hip circumference (cm)	0.647	0.572–0.718	0.006*	$\leq 94.50$	66.7	60.8
Waist-height ratio	0.649	0.573–0.719	0.013*	$\leq 0.52$	66.7	64.3
Waist-hip ratio	0.640	0.564–0.711	0.014*	$\leq 0.87$	69.7	58.7
MUAC (cm)	0.652	0.577–0.722	0.006*	$\leq 26.00$	60.6	67.1
Calf circumference (cm)	0.703	0.630–0.770	<0.001**	$\leq 30.50$	54.6	86.7
TSF thickness (mm)	0.655	0.580–0.725	0.005*	$\leq 26.00$	66.7	62.2
15-foot walk (min)	0.558	0.482–0.633	0.307	> 7.58	36.4	78.3
Hand grip strength (kg)	0.542	0.465–0.617	0.474	$\leq 16.33$	27.3	86.0
MNA-SF score	0.910	0.858–0.948	< 0.001**	$\leq 10.00$	66.7	95.1

**Notes:** \*Statistically significant at *P* < 0.05. \*\*Statistically significant at *P* < 0.001.

**Abbreviations:** AUC, area under the curve; BMI, body mass index; MUAC, Mid-upper arm circumference; TSF, Triceps skinfold; MNA-SF, Short Form Mini Nutritional Assessment.

**Table 2** The Sensitivity, Specificity, PPV, NPV, LR+, LR- and Accuracy of the MNA-SF Compared with the Full MNA (n=176)

Outcome of the MNA-SF Compared with the Full MNA	Value	95% CI
Sensitivity	78.79%	61.09%–91.02%
Specificity	81.82%	74.51%–87.77%
Positive Likelihood Ratio	4.33	2.93–6.40
Negative Likelihood Ratio	0.26	0.13–0.50
Positive Predictive Value	50.00%	40.37%–59.63%
Negative Predictive Value	94.35%	89.61%–97.01%
Accuracy	81.25%	74.69%–86.73%

**Abbreviations:** PPV, positive predictive value; NPV, negative predictive value; LR+, positive likelihood ratio; LR-, negative likelihood ratio; MNA-SF, Short Form Mini Nutritional Assessment.

of weight loss greater than 3 kg was 3.98%. All participants (100%) lived independently and self-fed without any problems. Only 1.14% perceived themselves to be malnourished. A majority of participants perceived their nutritional status to be as good as (51.14%) or better than others (34.66%).

## The AUC, Cut-off, Sensitivity and Specificity of Functional Assessments, Anthropometric Measurements and MNA-SF Score to Predict Abnormal Nutritional Status

Table 1 shows the AUC of calf circumference is 0.703 and has a sensitivity of 54.6% and specificity of 86.7% when using cut-off  $\leq 30.50$  cm. The outcome of the AUC and ROC curve in Figure 2 demonstrates that the calf circumference has acceptable accuracy in classifying abnormal nutritional status. The AUC of the MNA-SF score is 0.910, highest when compared with other tests and has a sensitivity of 66.7% and specificity of 95.1% when using cut-off  $\leq 10$ . The outcome of the AUC and ROC curve in Figure 3 demonstrates that the MNA-SF total score has excellent accuracy in classifying abnormal nutritional status.

## The Sensitivity, Specificity, PPV, NPV, LR+, LR- and Accuracy of the MNA-SF Compared with the Full MNA

The true positive rate was 26/176, the false positive rate was 26/176, the true negative rate was 117/176 and the false negative rate was 7/176. The sensitivity, specificity, LR+, LR-, PPV, NPV and accuracy are shown in Table 2.

**Table 3** Characteristics of the Elderly Participants (n=176)

Characteristics	Number	(%)
<b>Age (years)</b>		
60–69	94	53.41
70–79	58	32.95
≥80	24	13.64
<b>Sex</b>		
Male	75	42.61
Female	101	57.39
<b>Marital status</b>		
Single	17	9.66
Married	127	72.16
Widowed	32	18.18
<b>Religion</b>		
Buddhism	170	96.60
Islam	6	3.40
<b>Education</b>		
None	7	3.98
Primary education	79	44.89
Elementary education	17	9.66
Junior high school	15	8.52
Senior high school	20	11.36
Vocational certificate	11	6.25
Bachelor's degree	27	15.34
<b>Underlying disease</b>		
No	36	20.45
Yes	140	79.55
<b>Body mass index (kg/m<sup>2</sup>)</b>		
Underweight (BMI <18.5)	13	7.39
Normal (BMI 18.5–22.9)	64	36.36
Overweight (BMI 23–24.9)	34	19.32
Obese I (BMI 25–29.9)	48	27.27
Obese II (BMI ≥ 30)	17	9.66
<b>Nutritional status according to the MNA-SF</b>		
Malnourishment	5	2.84
At risk of malnutrition	47	26.70
Normal nutritional status	124	70.46
<b>Nutritional status according to the full MNA</b>		
Malnourishment	4	2.27
At risk of malnutrition	29	16.48
Normal nutritional status	143	81.25
<b>Current working status</b>		
No	84	47.73
Yes	92	52.27
<b>Lives alone</b>		
No	160	90.91
Yes	16	9.09

(Continued)

**Table 3** (Continued).

Characteristics	Number	(%)
<b>History of hospital admission in last year</b>		
No	134	76.14
Yes	42	23.86
<b>History of falling in the last year</b>		
No	133	75.57
Yes	43	24.43
<b>Smoking</b>		
Never smokers	133	75.57
Former smokers	19	10.80
Current smokers	24	13.64
<b>Alcohol consumption</b>		
Never drinkers	134	76.14
Former drinkers	16	9.09
Current drinkers	26	14.77
<b>Exercise</b>		
No	25	14.20
Yes	151	85.80

**Abbreviations:** BMI, body mass index; MNA-SF, Short Form Mini Nutritional Assessment.

## Correlation Between Anthropometric Variables, 15-Foot Walk, Handgrip Strength and MNA Total Score

There was a significant positive correlation between body weight, BMI, waist circumference, hip circumference, waist-to-height ratio, waist-to-hip ratio, mid-upper arm circumference, calf circumference, triceps skinfold thickness and MNA-SF total score using the partial correlation coefficient after controlling for age and sex. There was no significant correlation between the handgrip test and MNA-SF total score using the partial correlation coefficient after controlling for age and sex, as shown in Table 5. There was a significant positive correlation between body weight, BMI, waist circumference, hip circumference, waist-to-height ratio, waist-to-hip ratio, mid-upper arm circumference, calf circumference, triceps skinfold thickness, handgrip strength and full MNA total score by partial correlation coefficient after controlling for age and sex. There was no significant correlation between the 15-foot walk and full MNA total score using the partial correlation coefficient after controlling for age and sex, as shown in Table 5.

## Discussion

This study demonstrated that there was a significant positive correlation between body weight, BMI, WC, HC,

**Table 4** Outcome of MNA Nutritional Assessment 18 Items (n=176)

Outcome of Nutritional Assessment	Number	(%)
<b>Food intake decline</b>		
Severe decrease	5	2.84
Moderate decrease	34	19.32
No decrease	137	77.84
<b>Weight loss</b>		
Greater than 3 kg	7	3.98
Between 1 and 3 kg	33	18.75
No weight loss	136	77.27
<b>Mobility</b>		
Goes out	176	100.00
<b>Stress/disease</b>		
No	157	89.20
Yes	19	10.80
<b>Neuropsychological problems</b>		
Mild dementia	74	42.05
No psychological problem	102	57.95
<b>BMI (kg/m<sup>2</sup>)</b>		
Less than 19	14	7.95
19 to less than 21	19	10.80
21 to less than 23	44	25.00
23 or greater	99	56.25
<b>Lives independently</b>		
Yes	176	100.00
<b>Takes &gt;3 prescriptions</b>		
No	124	70.45
Yes	52	29.55
<b>Pressure ulcer or skin ulcers</b>		
No	170	96.59
Yes	6	3.41
<b>Number of full meals</b>		
1 meal	1	0.57
2 meals	60	34.09
3 meals	115	65.34
<b>Protein score</b>		
Score 0	21	11.93
Score 0.5	60	34.09
Score 1	95	53.98
<b>Two or more servings of fruits</b>		
No	11	6.25
Yes	165	93.75
<b>Consumed fluid</b>		
Less than 3 cups	35	19.89
3 to 5 cups	28	15.91
More than 5 cups	113	64.20

(Continued)

Table 4 (Continued).

Outcome of Nutritional Assessment	Number	(%)
<b>Mode of feeding</b>		
Self-fed without any problem	176	100.00
<b>Self-view of nutritional status</b>		
View self as being malnourished	2	1.14
Is uncertain of nutritional state	32	18.18
View self as having no nutritional problem	142	80.68
<b>Compare with others</b>		
Not as good	12	6.82
Does not know	13	7.38
As good	90	51.14
Better	61	34.66
<b>MUAC (cm)</b>		
Less than 21	1	0.57
21 to 22	6	3.41
Greater than 22	169	96.02
<b>CC (cm)</b>		
Less than 31	37	21.02
31 or greater	139	78.98

**Abbreviations:** MUAC, Mid-upper arm circumference; CC, calf circumference.

WHtR, WHR, MUAC, CC, TSF thickness and MNA-SF total score using the partial correlation coefficient after controlling for age and sex. There was no significant correlation between the gait speed test and handgrip test with MNA-SF total scores. The previous studies in

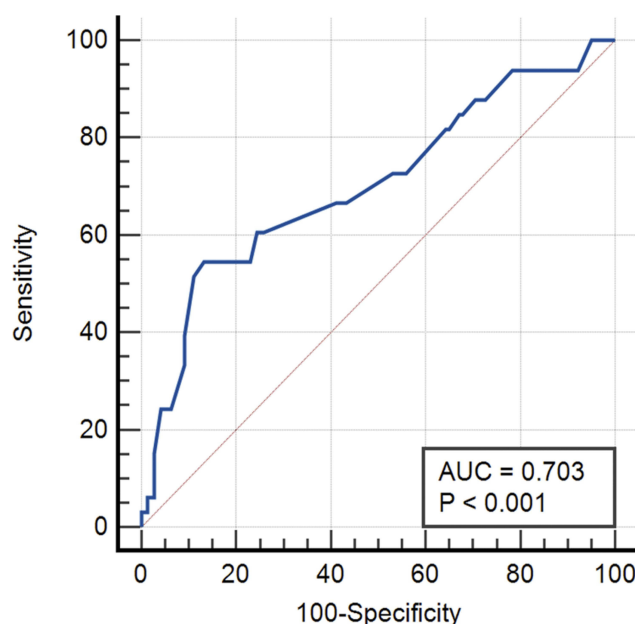


Figure 2 ROC curve of calf circumference.

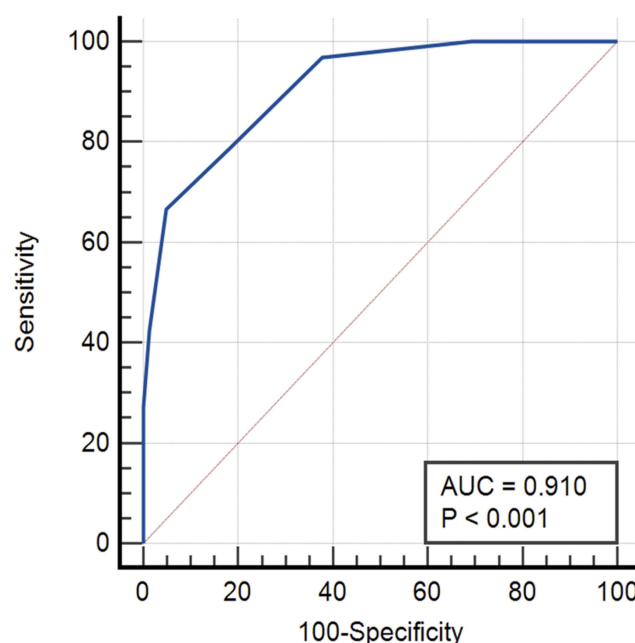


Figure 3 ROC curve of MNA-SF.

Ethiopia showed the same outcome: body weight, BMI, MUAC and CC had a significant positive correlation with MNA-SF total score.<sup>44</sup> This demonstrates the utility of the MNA-SF for evaluating nutritional status, as it is easy and available for use in OPD and community settings, and it correlates with many anthropometric measurements. However, the previous studies demonstrated that WC,

Table 5 Correlation Between Anthropometric Variables, 15-Foot Walk, Handgrip Strength and MNA Total Score (n=176)

Anthropometric Variables	MNA-SF Total Score	P value	Full MNA Total Score	P value
	r <sub>1</sub>		r <sub>2</sub>	
Body weight (kg)	0.439	<0.001**	0.312	<0.001**
BMI (kg/m <sup>2</sup> )	0.375	<0.001**	0.201	0.008*
Waist circumference (cm)	0.469	<0.001**	0.308	<0.001**
Hip circumference (cm)	0.436	<0.001**	0.289	<0.001**
Waist-height ratio	0.420	<0.001**	0.232	0.002*
Waist-hip ratio	0.326	<0.001**	0.225	0.003*
MUAC (cm)	0.386	<0.001**	0.295	<0.001**
Calf circumference (cm)	0.334	<0.001**	0.353	<0.001**
TSF thickness (mm)	0.327	<0.001**	0.287	<0.001**
15-foot walk (min)	0.068	0.376	-0.047	0.542
Hand grip strength (kg)	0.128	0.093	0.183	0.016*

**Notes:** \*Statistically significant at  $P < 0.05$ . \*\*Statistically significant at  $P < 0.001$ , partial correlation coefficient of the MNA-SF ( $r_1$ ) and the full MNA ( $r_2$ ).

**Abbreviations:** MNA-SF, Short Form Mini Nutritional Assessment; BMI, body mass index; MUAC, mid-upper arm circumference; TSF, triceps skinfold.



HC, WHtR, WHR were common used in the screening risk of cardiovascular disease more than used for screen risk of malnutrition.<sup>45,46</sup>

This study demonstrated that there was a significant positive correlation between body weight, BMI, WC, HC, WHtR, WHR, MUAC, CC, TSF thickness, handgrip strength and full MNA total score using the partial correlation coefficient after controlling for age and sex. The AUC of calf circumference is 0.703 and has a sensitivity of 54.6% and specificity of 86.7% when using cut-off  $\leq 30.50$  cm. This study found that the gait speed test was not significantly correlated with the full MNA score. Previous studies in Ethiopia showed the same outcome: body weight, BMI, MUAC and CC had significant positive correlations with full MNA score.<sup>44,47</sup> A correlation between MNA score and the handgrip test was only found for the full MNA. A previous study in Indonesia showed the same outcome: the handgrip test demonstrated a significant positive correlation between handgrip strength and nutritional status as determined by the full MNA.<sup>48</sup> Aging affects muscle function and decreases muscle strength.<sup>48</sup> Nutritional status can also affect muscle strength, and handgrip strength can thus be applied as a marker of nutritional status and predictor of disability.<sup>49</sup>

The prevalence of malnourished group was 2.27% when using the full MNA, which was a higher prevalence than that in a previous study in Taiwan (2% in total participants by using full MNA).<sup>50</sup> The prevalence of at risk of malnutrition was 16.48% when using the full MNA, which was higher than that found in the same previous study in Taiwan (13.1% when using full MNA).<sup>50</sup> The Taiwanese study had a similar setting among non-Caucasian elderly individuals. The prevalence of malnourished group was 2.27% when using the MNA-SF, and this finding was lower than the prevalence in Saudi Arabia 47.6% among hospitalized elderly individuals and Sri Lanka 12.5% among community-dwelling elderly.<sup>7,20</sup> The prevalence of at risk of malnutrition was 26.70% when using the MNA-SF, which was lower than the prevalence among hospitalized elderly individuals in Saudi Arabia (29.03%) and Sri Lanka (52.4%).<sup>7,20</sup> The previous study in Saudi Arabia had a different setting—in the hospital—and participants had existing diseases during admission. Disease can increase the risk of malnutrition, and the duration of admission can affect food intake; the present study was conducted in a community setting. Furthermore, though the study in Sri Lanka was in a community setting, the outcomes measured were

different; the differing results might be due to cultural differences in food intake and population demographics. Despite these disparate results, we can apply the full MNA and the MNA-SF for use in community, primary care and hospital settings.

This study demonstrated that the MNA-SF had sensitivity of 78.79%, specificity of 81.82%, PPV of 50%, NPV of 94.35%, LR+ of 4.33, LR- of 0.26, accuracy of 81.25% and AUC 0.901 when using the full MNA as a reference standard. The MNA-SF has the highest specificity, NPV and accuracy; this test would be useful for diagnosis. The previous studies also demonstrate MNA-SF had good sensitivity, specificity and correlation with full MNA to detect community-dwelling older adults at risk of malnutrition.<sup>51,52</sup> However, this test has an LR+ of 4.33, showing that this tool has a moderate effect on the outcome of nutrition status. This tool should be evaluated in combination with another tool, such as anthropometric measurements or serum albumin levels.<sup>53–55</sup> A previous study in the Balçova district of the province of Izmir in Turkey showed that the correlation between the MNA-SF and full MNA was strong, significant and almost identical in the community and in nursing homes ( $r = 0.86–0.88$ ;  $P < 0.001$ ); the study also demonstrated that the MNA-SF had similarly high sensitivity and selectivity in the community setting as the full MNA.<sup>52</sup> A previous study in Ethiopia demonstrated that the MNA-SF had a sensitivity of 85.7% and specificity of 89% when using the Youden index as the best cutoff point to detect malnutrition.<sup>44</sup> However, venipuncture for laboratory tests, such as serum albumin levels among elderly individuals in the community setting, is not always available, and pain can occur at the venipuncture site.<sup>56</sup> Furthermore, the complications of venipuncture include bruising, cellulitis and hematoma at the venipuncture site.<sup>57</sup> The MNA-SF has 6 items, and the full MNA has 18 items;<sup>6,8</sup> the MNA-SF would be useful and available for screening nutritional status before laboratory examination. The MNA-SF and full MNA can be useful for screening risk of malnutrition when participants do not consent to venipuncture in the community setting, primary care or outpatient setting in the hospital to evaluate nutritional status among the elderly. However, the MNA-SF and full MNA cannot be used to replace laboratory results.

The full MNA collects more detailed data on food intake, protein intake, fluid intake and physical examination, such as MUAC and CC, than the MNA-SF. The full

MNA is appropriate for the hospital setting when there is enough time to administer it, because it has many items. The MNA-SF is available and may be easier to use than the full MNA to assess nutritional status when time is limited, such as in community and primary care settings. Overall, both versions of the MNA can be used to assess nutritional status among the elderly population in community, primary care and hospital settings.

## Study Limitation

The true height in the elderly is difficult to measure by standing position because their height has decreased in advanced age. Further study should be the focus on more outcomes in the larger population.

## Conclusions

This study demonstrates that the MNA-SF and full MNA correlated with many anthropometric measurements. The MNA-SF has high specificity, NPV and accuracy of more than 80% when compared with the full MNA. The MNA-SF can be used to assess nutritional status among elderly individuals when there are time limitations. The MNA-SF and full MNA can be applied to assess nutritional status among elderly individuals in community, primary care and hospital settings.

## Ethical Approval

The study was reviewed and approved by the Ethics Committee on Human Rights Related to Research Involving Human Subjects, Walailak University, prior to the recruitment of participants (WUEC-20-112-01).

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## Disclosure

The authors reported no conflicts of interest for this work and declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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