# Which Muscle Mass Measurement Should we Prefer in the Global Leadership Initiative on Malnutrition Criteria?

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## Abstract

Objectives: The first aim of our study was to evaluate the malnutrition rates of patients separately with four different phenotypic methods (Calf Circumference (CC), Middle Arm Circumference (MAMC), Fat Free Mass Index (FFMI), and Handgrip Strength (HGS)) that define reduced muscle mass with the Global Leadership Initiative on Malnutrition (GLIM).The study's first aim was to determine the frequency of MN according to (Mini Nutritional Assessment) MNA and the GLIM criteria. The second aim was to evaluate the relationship between the energy and content of the foods consumed daily by older adults and four different phenotypic methods. Methods: The study included 238 outpatients. Anthropometric measurements, body composition and HGS of the patients were evaluated. The dietician recorded the 24-hour food consumption records of the patients. Results: The median age of outpatients included in the study was 68(60-85). The median Basal metabolic Index (BMI) value of the outpatients was 30.7(16.9-61.2). GLIM-MAMC was 26.9%, GLIM-CC was 28.1%, GLIM-FFMI was 31.5%, GLIM-HGS was 31.9%, and GLIM-2F+2E, 21.4% of outpatients. Conclusion: One of the most practical and straightforward methods to determine malnutrition in geriatric outpatients is the MAMC, which is more meaningful with food consumption recording. However, the method that determines the highest rate of MN according to HGS is the GLIM. By using these methods, the malnutrition of patients will not be neglected.


## 1. Introduction

Malnutrition is the clinical condition that results from insufficient intake of the nutrients the body needs. With aging, changes in body composition, energy needs and usage, and functions of organs occur.(1) Another factor that puts the elderly at risk is loss of taste or smell. This deterioration affects the eating habits of older adults and leads them to anorexia. In addition, multiple drug use, comorbid diseases, social isolation, financial deprivation, psychological problems, decreased food intake due to dysphagia or skipping meals, and other neurological problems are among the causes of malnutrition due to aging.(2-4) Studies have shown that approximately 27-50% of geriatric outpatients have malnutrition (MN).(5)

Diagnosing malnutrition in geriatric outpatients is often overlooked due to the lack of intensity, staff, or materials used during examinations. To determine malnutrition early in the clinical setting, global screening tools using validated techniques are needed. For this purpose, many screening tools have been developed. Still, no one screening tool can be called the "gold standard."(6) Using an accurate screening tool to describe malnutrition in outpatient geriatric patients is crucial for improving patients' quality of life.

The Mini Nutritional Assessment (MNA) is a specially designed tool for screening malnutrition in geriatric patients. It consists of anthropometric measurements, general information, diet information, and individual evaluation sections.(7) Recently, GLIM was published to establish a global consensus around essential diagnostic criteria for malnutrition in adults in clinical settings.(8) GLIM criteria suggest a nutritional assessment including phenotypic and etiological criteria to assess nutritional risk. At least one phenotypic criterion and one etiological criterion must be present in patients to diagnose the presence of malnutrition.(9) Consensus proposes several validated techniques such as dual-energy X-ray absorptiometry, bioelectrical impedance analysis, computed tomography, or magnetic resonance imaging to estimate muscle mass. GLIM accepts the BIA method to identify reduced muscle mass. Fat-free mass (FFM) measurement may not always be possible depending on the clinician's time limitation per patient or hospital facility; fat-free mass (FFM) measurement may not always be possible. Muscle mass assessment can be done with anthropometric measurements and HGS, but few studies compare these measurements with validated techniques. With these techniques, the malnutrition status of outpatient can be done faster and be more practical. It can be more beneficial to evaluate malnutrition and nutritional status of patients with anthropometric measurements such as calf circumference (CC), mid-arm muscle circumference (MAMC), or handgrip strength test (HGS) that can be used in a busy outpatient clinic.(10)

The first aim of our study was to evaluate the malnutrition rates of patients separately with four different phenotypic methods that define reduced muscle mass with GLIM. Thus, we would be able to find a method that would minimize the overlook of the MN frequency. The second aim was to evaluate the relationship between the energy and content of the foods consumed daily by older adults and four different phenotypic methods. These are important for avoiding overlooking older adults' daily nutritional status in nutritional screening and evaluation tests.

## 2. Materials And Methods

This was a cross-sectional study performed with 238 patients aged 60 years or older who applied to the Geriatric Clinic. Local Ethics Committee approval was obtained before starting the study, and the patients were informed about the purpose of the study, and informed written consent was obtained.

### *2.1. Evaluation of Nutritional Status of Patients*

The dietician recorded the food consumed for 24 hours and their amounts (cups, mugs, teaspoons, tablespoons, etc.). This information was analyzed using the BeBiS software developed for the national nutrition program. Patients who received energy and macronutrients were evaluated.(11)

### *2.2. Evaluation of Malnutrition According to GLIM Criteria*

Phenotypic criteria were evaluated according to reluctant weight loss (<5% in 6 months) and low BMI (<20 kg/m2 in <70 years). Bodyweight (kg) was measured with a precision scale using a standard technique. The height of outpatients was measured using a wall-mounted stadiometer (Holtain, UK) with an accuracy of ± 1mm. BMI was calculated using the formula BMI = Weight (kg) / Height ($m^2$).(12) Etiological criteria were evaluated according to the 24-hour food consumption records taken from the patients and the presence of an acute inflammatory state at the time of admission to the outpatient clinic. 24-hour food consumption records were obtained from the patients, and they were questioned whether they had a reduced food intake. We calculated the energy received by the patients with a 24-hour food consumption record, and we evaluated those with below 50% of the energy should be noted according to GLIM criteria as having a reduced food intake. Patients were also asked about their acute illness or chronic diseases related to inflammation status. Patients with any phenotypic criteria were recorded as having malnutrition if they met one of the etiological criteria.(8)

#### *2.2.1. GLIM criteria using basic techniques*

In the presence of reluctant weight loss or low BMI with phenotypic criteria, if there was a decrease in food intake or inflammation from the etiological criteria, patients were accepted as having malnutrition [(A or B) + (D or E)]. GLIM criteria without using reduced muscle mass were defined as GLIM-2F+2E.

#### *2.2.2. GLIM criteria using calf circumference*

Calf circumference was measured with the patient sitting on the floor and at the maximum circumference with the leg positioned at an angle of 90°. Calf circumference values less than 31 cm were accepted for a patient having the risk of malnutrition.(13) According to calf circumference, in outpatients with malnutrition risk (MN-CC), if there were any etiological criteria, it was defined as "GLIM-CC" [(C1) + (D or E)].

#### *2.2.3. GLIM Criteria using mid-arm muscle circumference*

Patients were told to stand upright during the measurement of the upper-middle arm circumference and to leave their right arm loose. The olecranon and acromion points of the patients were determined, and the upper-middle arm circumference was measured from the midpoint of the two. The same researcher performed the triceps skinfold measurement three times using the Holtain constant pressure caliper (Holtain Limited, Crymych, England). The average was calculated according to the recommendations of SEEN (Sociedad Española de Endocrinología y Nutrición).(14) The MAMC cut-off points are below 19.2 cm in females and 21.1 cm in males, and when the patients' measurements were below these, they were considered a risk of malnutrition.(15) According to the MAMC, in outpatients with malnutrition risk (MN-MAMC), if there were any etiological criteria, it was defined as "GLIM-MAMC" [(C2) + (D or E)].

#### *2.2.4. GLIM criteria using fat-free mass index*

A multi-frequency Bioelectrical impedance analysis (BIA) device (Bodystat Quad Scan 1500, UK) evaluated body composition. The measurements were made in the supine position. Two electrodes were placed on the hand and wrist and the foot and ankle. Data from the patients regarding fat mass (FM, kg), fat-free mass (FFM, kg), and resistance in ohms were obtained from the BIA measurements. FFMI was calculated as the ratio of FFM to the square of the person's height in meters.(16) When the FFMI cut-off points were below 15 kg/m$^2$ in females and 17 kg/m$^2$ in males, they were considered as having a risk of malnutrition.(17) According to the FFMI, in outpatients with malnutrition risk (MN-FFMI), if there were any etiological criteria, it was defined as "GLIM-FFMI" [(C3) + (D or E)].

#### *2.2.5. GLIM criteria using handgrip strength*

Muscle strength was assessed by handgrip strength (HGS) with a dynamometer (Takei TKK 5401 Digital Handgrip Dynamometer, Niigata-City, Japan). The participants were requested to hold the dynamometer in the dominant hand with the elbow flexed at 90$^0$ and the forearm parallel to the floor. The HGS score was defined as the best performance of three trials. When HGS cut-off points were below 20 kg in females and 30 kg in males, they were considered malnutrition risk.(18) According to the HGS, in outpatients with malnutrition risk(MN-HGS), if there were any etiological criteria, it was defined as "GLIM-HGS" [(C4) + (D or E)].

## 3. Results

The study included 238 older adults (148 females and 90 males). The median age of males was 69 (60-85), and the median age of females was 67 (60-86). The median BMI value of the males was 27.8 (16.9-47.2.2), and the median BMI value of the females was 32.4 (19.7-61.2) kg/m$^2$. Detailed demographic data of the older adults are shown in Table 1.

The patients were first screened for MNA. The FFMI value found by BIA measurement was used as the reference method as it is the only method recommended and validated by GLIM.

Then, MN due to reduced muscle mass was evaluated by MAMC, CC, and HGS methods.

According to MNA screening, while 10.1% of older adults are at risk of malnutrition, 33.6% have malnutrition. While MN-MAMC was in 7.6% of the older adults, GLIM-MAMC was 26.9% (p: 0.042). While MN-CC was in 10.9% of older adults, GLIM-CC was in 28.1% (p: 0.074). MN-FFMI was 21.4% of the older adults, and GLIM-FFMI was 31.5% (p: 0.045). MN-HGS was 29% of the older adults, and GLIM-HGS was 31.9% (p: 0.141). According to GLIM-2F+2E, 21.4% of older adults had malnutrition (Figures 1 and 2). MN-(MAMC, CC, FFMI, HGS) rates and GLIM-(MAMC, CC, FFMI, HGS) rates in males and females are detailed in Figure 2.

According to GLIM-MAMC showed that the median malnourished female outpatients' calorie intake was 853 (272-3350) kcal, and the median female normal nutrition (NN) outpatients' calorie intake was 1026 (329-2444) kcal (p: 0.01). According to GLIM-MAMC, the median male malnourished outpatient calorie intake was 876 (272-3350) kcal, the median male NN outpatients' calorie intake was 1071 (272-3350) kcal (p: 0.008). According to GLIM-2F+2E evaluation, the median female malnourished outpatients' calorie intake was 843 (272-2360) kcal, and the median female NN outpatients' calorie intake was 1006 (329-3350) kcal (p: 0.01). According to GLIM-2F+2E, the median male malnourished outpatients' calorie intake was 864 (272-2360) kcal, and the median female NN outpatients' calorie intake was 1042 (272-3350) kcal (p: 0.01). Detailed information is shown in Figure 2.

In all the methods used to estimate reduced muscle mass (MAMC, CC, FFMI, HGS), age was significantly higher in malnourished older adults than normal, nourished older adults. According to GLIM, malnutrition screening was performed using MAMC, CC, FFMI and without using reduced muscle mass. BMI was significantly lower in malnourished outpatients compared to normally nourished outpatients. According to GLIM-MAMC and GLIM-2F+2E, the energy intake of malnourished outpatients was substantially lower than in normally nourished outpatients.

In all the methods used to estimate reduced muscle mass (MAMC, CC, FFMI, HGS), there was no significant difference in protein intake among malnourished outpatients compared to normally nourished outpatients. According to the GLIM-MAMC, carbohydrate intake was significantly lower in malnourished outpatients compared to normally nourished outpatients. Detailed malnutrition screenings of older adults are given in Table 2.

# 4. Discussion

The frequency of malnutrition in older adults depends on population, geography, age, socioeconomic status, and the screening tools used. The frequency of malnutrition was determined in 33.6% of our study group according to the MNA. GLIM criteria are currently used to determine malnutrition. To determine malnutrition according to these criteria, outpatients are generally questioned about weight loss, nutritional intake, and inflammation status. However, there are many validated techniques in GLIM criteria that can determine low muscle mass. We compared these methods to determine which techniques could be more meaningful, reliable, and valuable.

Our study found that when evaluated with the MAMC, CC, FFMI, HGS, and without using reduced muscle mass, GLIM resulted in an age increase with malnutrition development in outpatients. Outpatients, who develop malnutrition with the advancement of age, decrease their BMI values. Studies have found that age was an independent risk factor for malnutrition (19).

As far as we know, our study is the first study on GLIM criteria created by evaluating different muscle masses in older adult outpatients. Based on the results of this study, we considered which of the phenotypic criteria used in GLIM studies in the literature should be given in detail in the method section. Our study detected malnutrition as 26.9% when using MAMC, 28.1% when using CC, 31.5% when using FFMI, and 31.9% when using HGS to determine muscle strength, which was taken as one of the phenotypic criteria. When GLIM-2F+2E was evaluated, the frequency of malnutrition was lower (21.4%), and approximately 10% of outpatients were missed when reduced muscle mass was not in use.

In our study, 24-hour food consumption records, which we consider a strength of our study, were not found in the literature. Patients with malnutrition according to GLIM, which was determined using different muscle mass evaluation methods, were compared. According to the protein requirement of the European Parenteral and Enteral Nutrition Association (ESPEN) guidelines, 55% of males and 58% of females reached their target protein at the end of the day in our study. Morris et al. conducted a study to describe the protein intake of older adults. According to the ESPEN guidelines (20), less than 15% of the participants reached 1.2 g/kg/day intake levels. Sixty-seven percent of males and 77% of females reached the 25-g protein target in the middle of the day. (21) Calorie and carbohydrate intake were lower in both genders, especially in males diagnosed with MN using the GLIM-MAMC.

Handgrip strength has been a superior outcome marker for healthy people and patients, especially in older adults. FFMI found by BIA measurement is the only method recommended and validated by GLIM, so we used it as a reference. In our study, when handgrip was included in GLIM criteria, the rate of malnutrition was 31.9% in older adults. The MN ratio found by the GLIM-HGS method gave the closest value to the MN ratio in the reference method. Therefore, even if HGS is used instead of FFMI in clinics without BIA, MN will not be ignored. HGS assessment gives the closest rate to malnutrition in patients scanned with the MNA. Some studies have emphasized low handgrip strength was consistent with the possibility of early death, early disability, increased risk of complications, length of hospitalization, or prolonged stay after surgery.(22) Bolivar et al. conducted a prospective study to determine the prevalence of malnutrition in cancer patients. They evaluated the most compatible malnutrition rates by taking Subjective Global Assessment (SGA) and some anthropometric measurements of the patients. SGA and GLIM criteria (especially with HGS) were found to be the most valuable tools in the diagnosis of malnutrition and evaluation of six-month mortality.(10)

In our study, the CC was the best indicator of the number of malnourished older adults after the HGS and FFMI. Bonnefoy et al. studied 911 geriatric patients to determine nutritional status. The study investigated the method that gives the best correlation value between biochemical methods (albumin, transthyretin, transferrin, retinol-binding protein, and a1-acid glycoprotein) and anthropometric methods (upper-middle arm circumference, calf circumference, and skinfold thickness). The anthropometric method that determined the best nutritional status in the study showed that the CC was the best.(23) In a study by Drescher et al., the MNA and Nutritional Risk Screening (NRS) scores were high in geriatric patients with low CC (24).

In our study, GLIM-MAMC, malnutrition was found at 26.9%, while the mean MAMC of malnourished female outpatients was 18.8±1.9 cm, and the mean of malnourished male outpatients was 18.6±1.3 cm. In a study by Bolivar et al., GLIM-MAMC evaluation of cancer patients was followed. In the SGA evaluation of the patients, 25.5% had moderate MN, and 56.1% had severe MN. In GLIM-MAMC evaluation, they found MN in 72.2% of the patients. This is the most similar study to ours, and the reason for higher MN rates is that the patient group had cancer. Our patient group consisted of outpatients from general society.

A study comparing GLIM criteria with reduced food intake, one of the malnutrition evaluation parameters, could not be identified in the literature. Hanisah et al., in their study, assessed malnutrition using SGA and anthropometric measurements, and food intake was measured using the Dietary History Questionnaire. While 50.4% of the patients were moderately malnourished, 11% were found to be severely malnourished. According to MN-MAMC, rates were found to be 10.9% in males and 3% in females. According to MN-CC, rates were found as 34.8% in males and 20.2% in females.(25) In our study, when according to MN-MAMC, the rate was found as 7.6% (7.8% in males and 7.4% in females). When according to MN-CC was determined, the rate was found as 10.9% (10% in males and 11.5% in females). However, when malnutrition was evaluated using the GLIM-MAMC, the rate of MN increased to 20% in males and 31.1% in females. Likewise, when malnutrition was evaluated using the GLIM-CC, the rate of MN increased to 22.2% in males and 31.8% in females. In other words, when MN is evaluated by only looking at the MN-MAMC or MN-CC values of the patients, MN rates are low; this can mislead us. According to GLIM-MAMC and GLIM-CC, food consumption records taken from patients are a valid etiological criterion in showing the malnutrition levels of the patients. Thus, we can prevent patients who need MN treatment from being overlooked.

In our study, calorie intake was 1188 ± 544 kcal in males, while it was 1080 ± 522 kcal in females. The percentage of males not reaching their target calories was 36.7%, while females not reaching their target calories was 34.5%. This MN ratio was found close to according to GLIM-MAMC, GLIM-CC, GLIM-FFMI, and

GLIM-HGS evaluation.

In our study, we calculated the energy received by the patients with a 24-hour food consumption record, and we evaluated those with below 50% of the energy they should receive according to GLIM criteria as having a reduced food intake. As a result, the MN ratio was determined as 21.4% with the GLIM-2F+2E. Although this study was conducted as a more objective evaluation, according to the evaluation made by taking the muscle mass into account, MN rates were found to be 5-10% missing. In other words, no matter how objective the 24-hour food consumption record is, which is one of the strengths of our study, it will always give better results when evaluated with muscle mass. In this case, when MN is evaluated GLIM-2F+2E instead of GLIM with muscle mass, results show that we overlook sarcopenic elderly individuals, a concept intertwined with malnutrition.

The strength of our study is that it was performed in an outpatient patient group with a higher incidence of more specific malnutrition. By taking a 24-hour food record, we evaluated the decrease in the food received by the patient with a more objective method. The fact that C-Reactive Protein determination was not routinely performed in every patient to evaluate the acute inflammation, which is one of the etiological criteria, can be considered a disadvantage of our study.

Clinically, the fastest, most practical, and cost-effective determination of malnutrition in geriatric outpatients is vital for both patients and healthcare professionals. GLIM is the most up-to-date method that includes many criteria to diagnose MN. According to our study, compared to other malnutrition diagnostic methods, GLIM better detects elderly patients with malnutrition that may be overlooked. A more objective assessment will be made when GLIM criteria are combined with the 24-hour food consumption record. In our study, "GLIM-HGS" was the validated technique that showed the most meaning after MNA in screening malnutrition status of outpatients. However, while the MNA determines the risk of malnutrition in older adults, GLIM shows the malnutrition status. Therefore, "GLIM- HGS" can be used instead of the MNA in outpatients.

In conclusion, when GLIM-2F+2E assessment was made by taking food consumption records, GLIM-MAMC was the most meaningful method for MN evaluation. Still, GLIM-HGS was the most meaningful and practical evaluation of muscle mass assessment in the clinic. With this method, it is easier to determine the malnutrition status of the outpatients, and it will not be overlooked.

## Declarations

**Ethics approval and consent to participate :** Local Ethics Committee approval was obtained before starting the study, and the patients were informed about the purpose of the study, and informed written consent was obtained.

**Consent for publication :** available

**Availability of data and materials :** not available

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**Statement of Authorship**

G. Sahin and Sibel Akin equally contributed to the conception and design of the research; G. Sahin and NT Ozer equally contributed to the acquisition and analysis of the data; G. Sahin, S. Akin and S. Sahin contributed to the drafted the manuscript and critically revised the manuscript. All authors critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

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## Tables

**Table 1.** General characteristics of patients

| | | |
|---|---|---|
| Age, (years) | *Median(min-max)* | |
| *Male* | | 68(60-86) |
| *Female* | | 67(60-86) |
| BMI, (kg/m$^2$) | *Median(min-max)* | |
| *Male* | | 30.7(16.9-61.2) |
| *Female* | | 32.4(19.7-61.2) |
| Waist/Hip, | *mean±SD* | |
| *Male* | | 0.97± 0.07 |
| *Female* | | 0.92*±0.08* |
| Calf circumference, (cm) | *mean±SD* | |
| *Male* | | 35.8*±4* |
| *Female* | | *36±4* |
| Handgrip Strength, (kg) | *Median(min-max)* | |
| *Male* | | 21(6.7-50) |
| *Female* | | *18(6.7-30)* |
| Triceps Skinfold Thickness, (mm) | *Median(min-max)* | |
| *Male* | *mean±SD* | 16(3-35) |
| *Female* | | 20.4*±6.5* |
| Mid-arm Muscle circumference, (cm) | *Median(min-max)* | |
| *Male* | | 29.7(20-42) |
| *Female* | | 30(20-42) |
| Fat Free Mass (kg) | *Median(min-max)* | |
| *Male* | | 41.2(21.6-76.5) |
| *Female* | | 38.6(21.6-58.2) |
| Fat Free Mass Index (kg/m$^2$) | *mean±SD* | |
| *Male* | | 17.3*±2.7* |
| *Female* | | *16.4±2.3* |

Abbreviations: BMI, Body Mass Index.

**Table 2.** Relationship between MN in GLIM assessment and 24-hour food consumption records

| Variables | GLIM -MAMC | | *p* | GLIM-CC | | *p* | GLIM-FFMI | | *p* | GLIM-HGS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MN(n=64) NN(n=174) | | | MN(n=67) NN(n=171) | | | MN(n=75) NN(N=163) | | | MN(n:76) | NN(n=1 |
| **Age, years** | 70(60-86) | 66(60-85) | **<0.001** | 70(60-86) | 67(60-85) | **<0.001** | 70(60-86) | 66(60-85) | **<0.001** | 71(60-85) | 66(60- |
| **Sex,** | | | | | | | | | | | |
| Female, n | 46 | 102 | 0.06 | 47 | 101 | 0.11 | 53 | 95 | 0.06 | 43 | 105 |
| Male, n | 18 | 72 | | 20 | 70 | | 22 | 68 | | 33 | 57 |
| BMI, kg/$m^2$ | 26.05 (19.7-41.4) | 31.85 (16.9-61.2) | **<0.001** | 26.2 (19.7-40.6) | 32 (16.9-61.2) | **<0.001** | 25.8 (16.9-40.6) | 32.4 (22.9-61.2) | **<0.001** | 31.1 (16.9-61.2) | 30.4 (19.7-55.1) |
| Waist/ hip | 0.93±0.07 | 0.95±0.08 | 0.24 | 0.93±0.06 | 0.94±0.08 | 0.26 | 0.92±0.06 | 0.95±0.08 | 0.21 | 0.95±0.06 | 0.93±( |
| Food consumption | | | | | | | | | | | |
| ***Female*** | | | | | | | | | | | |
| Calorie (kcal/day) | 853(272-3350) | 1026(329-2444) | **0.01** | 864(272-2360) | 1006(329-3350) | 0.09 | 902(272-3350) | 1006(329-2444) | 0.36 | 1004(272-2232) | 946(3 3350) |
| Protein (gr/day) | | | 0.37 | | | 0.85 | | | 0.68 | | |
| | 41(8-114) | 42(16-104) | | 46(8-78) | 40(16-114) | | 42(8-114) | 40(16-104) | | 38(8-78) | 42(17-114) |
| Carbohydrate (gr/day) | | | **0.03** | | | 0.14 | | | 0.69 | | |
| | 56(10-440) | | | 81(15-320) | | | 105(15-440) | | | 114(10-325) | |
| | | 112(10-325) | 0.27 | | 109(10-440) | 0.57 | | 105(10-325) | 0.57 | | 90(10-440) |
| Fat (gr/day) | | | | | | | | | | | |
| | 46(0-126) | | 0.8 | 46(0-91) | | 0.54 | 46(0-126) | | 0.90 | 46(0-111) | |
| Cholesterol(mg/day) | | 49(15-136) | | | 48(15-136) | | | 48(15-136) | | | 48(15-136) |
| | 100(0-250) | | | 100(0-225) | | | 100(0-250) | | | 100(0-225) | |
| ***Male*** | | | | | | | | | | | |
| | | 100(0-350) | **0.008** | | 100(0-350) | 0.19 | | 100(0-350) | 0.29 | | 100(0-350) |
| Calorie (kcal/day) | | | | | | | | | | | |
| | | | 0.19 | | | 0.96 | | | 0.46 | | |
| Protein (gr/day) | 876(272-3350) | | | 903(272-2360) | | | 914(272-3350) | | | 1020(272-2444) | |
| | | | **0.021** | | | 0.22 | | | 0.48 | | |
| Carbohydrate (gr/day) | | 1071(272-3350) | | | 1014(272-3350) | | | 1014(272-3350) | | | 990(2 3350) |
| | 44(8-114) | | 0.19 | 47(8-778) | | 0.8 | 46(8-114) | | 0.67 | 41(8-104) | |
| Fat (gr/day) | 84(10-440) | 44(8-114) | 0.65 | 105(15-320) | 42(8-114) | 0.44 | 105(15-440) | 43(8-114) | 0.8 | 141(10-325) | 45(8-1 |
| Cholesterol(mg/day) | | 114(10-440) | | | 109(10-440) | | | 109(10-440) | | | 104(1( 440) |
| | 46(0-126) | | | 51(0-101) | | | 50(0-136) | | | 50(0-136) | |
| | 100(0-250) | 50(0-136) | | 125(0-225) | 50(0-136) | | 100(0-350) | 50(0-136) | | 100(0-350) | 50(0-1 |
| | | 100(0-350) | | | 100(0-350) | | | 100(0-350) | | | 112(0-350) |

Abbreviations: BMI, Body Mass Index; CC, Calf Circumference; FFMI, Fat Free Mass Index; GLIM, Global Leadership Initiative in Malnutrition; HGS, Handgrip Strength; MAMC, Mid-arm Muscle Circumference; MN, Malnutrition; NN, Normal Nutrition.

## Figures

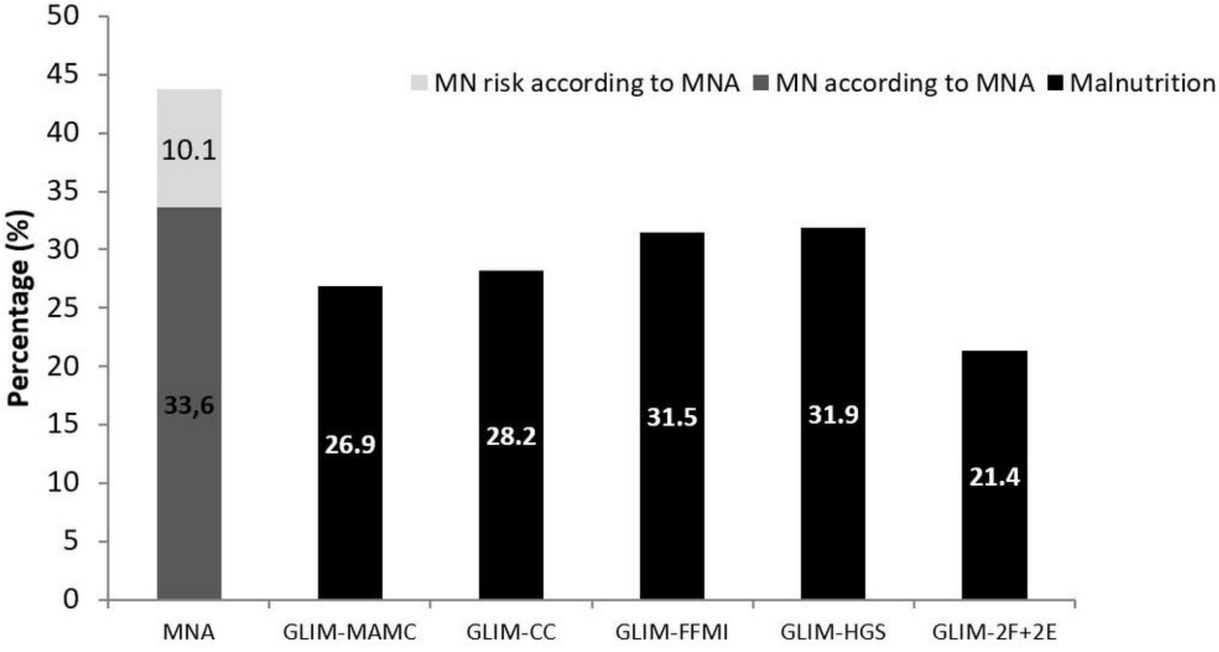


**Figure 1**

Percentage of malnutrition according to MNA and GLIM criteria

Abbreviations: CC, Calf Circumference; FFMI, Fat Free Mass Index; HGS, Handgrip Strength; MAMC, Mid-arm Muscle Circumference; MN, malnutrition; MNA, Mini Nutritional Assessment.

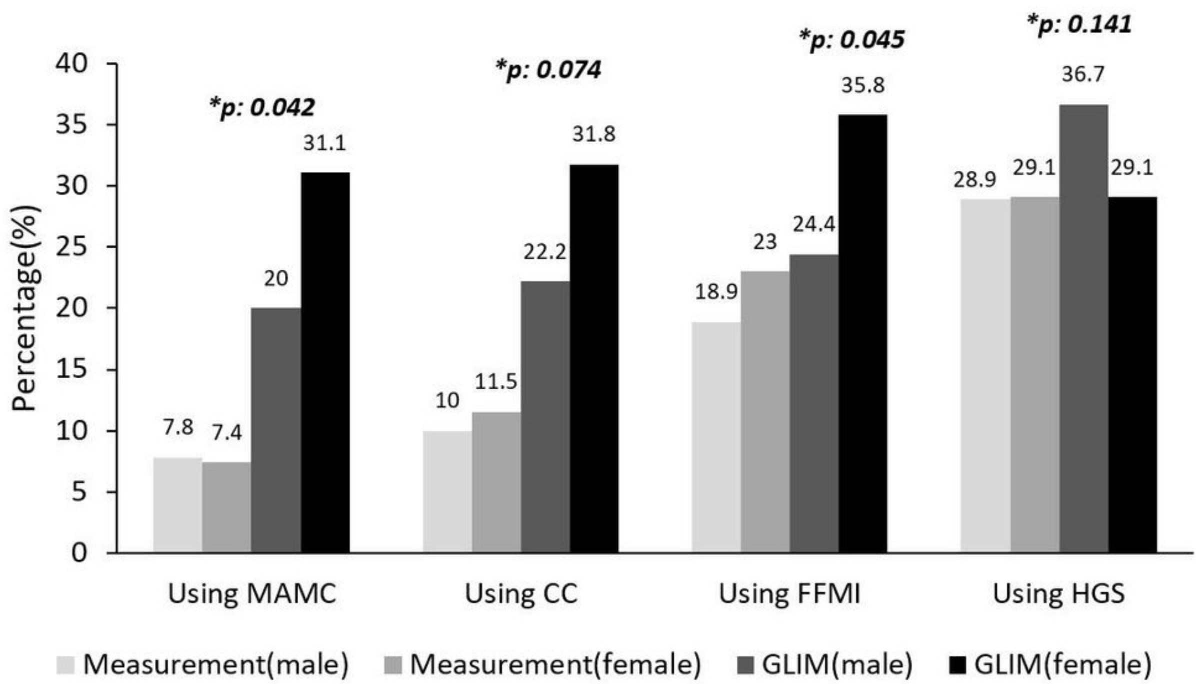


**Figure 2**

MN in measurement and MN in GLIM ratios in male and female

Abbreviations: CC, Calf Circumference; FFMI, Fat Free Mass Index; GLIM, Global Leadership Initiative in Malnutrition; HGS, Handgrip Strength; MAMC, Mid-arm Muscle Circumference.

* p values are between the ratios of MN-(MAMC,CC,FFMI,HGS) and GLIM-(MAMC,CC,FFMI,HGS).