European Journal of Environment and Public Health
2024, 8(4), em0164
e-ISSN: 2542-4904
https://www.ejeph.com

MODESTUM

Research Article

OPEN ACCESS

Prediction of malnutrition using combined index of different nutritional parameters in elderly home care patients

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Citation: Adıgüzel E, Acar-Tek N. Prediction of malnutrition using combined index of different nutritional parameters in elderly home care patients. EUR J ENV PUBLIC HLT. 2024;8(4):em0164. https://doi.org/10.29333/ejeph/15584

ARTICLE INFO

Received: 08 Aug. 2024

Accepted: 08 Oct. 2024

ABSTRACT

Aim: This descriptive and cross-sectional study was conducted to assess nutritional status in elderly home care patients using a combined index.

Methods: The combined index was calculated as a reference tool based on the results of five nutritional parameters (Mini Nutritional Assessment-Short Form [MNA-SF], Short Nutritional Assessment Questionnaire [SNAQ], body mass index, dietary energy, and dietary protein). If a patient was assessed as malnourished or undernourished in at least three of these five parameters, he/she was considered as "any stage of malnutrition" according to the combined index.

Results: The prevalence of malnutrition was 48.6%, 28.3%, and 47.4% according to the MNA-SF, SNAQ, and combined index, respectively. Dietary energy had the best sensitivity (92.7%) and negative predictive value (91.3%), while SNAQ had the highest specificity (100.0%) and positive predictive value (100.0%) according to the combined index. MNA-SF had the highest inter-rater agreement (kappa [κ]) with the combined index (κ =0.792).

Conclusions: The use of combined index based on both screening tools and other nutritional parameters could be effective in the diagnosis of malnutrition in elderly home care patients.

Keywords: home care, malnutrition, nutritional assessment, nutritional index

INTRODUCTION

The World Health Organization estimates that the number of older adults in the world (aged 60 and over) will reach 2.1 billion, and four-fifths of this population will be living in low- and middle-income countries by the year 2050 [1]. With the increase in elderly population, which becomes a global problem, health problems and the burden of health care costs will increase. The impact of these demographic changes on the health care system is already recognized in long-term care systems [2].

Malnutrition, which can be simply described as any nutritional imbalance, often occurs when nutrient intake is consistently inadequate to meet individual nutrient requirements. The imbalance between nutrition and nutrient requirements results in some changes that occur in body weight, body composition, and physical function [3]. The geriatric population has a high risk of malnutrition due to low metabolic rate, appetite loss, difficulty in chewing and swallowing, and different comorbidities [4]. In addition, limited mobility, psychological problems, being alone, illiteracy, poverty, and difficulty in access to health and social services make older adults more vulnerable to malnutrition, so that malnutrition causes an increase in morbidity and mortality [5]. Population studies in older adults show a wide range for the prevalence of malnutrition risk. In a meta-analysis presenting the results of 54 studies, the prevalence of malnutrition in community-dwelling older adults was reported in a wide range from 0% to 83%. Using different screening tools and the heterogeneity of the study samples were main reasons of this wide range [6]. In another meta-analysis with the results of 240 studies, malnutrition prevalence was tried to be determined in different health care settings: the prevalence of malnutrition was determined as 3.1% in the community-dwelling older adults, 6.0% in outpatients, 8.7% in home care patients, 22.0% in hospitalized patients, 17.5% in nursing home residents, 28.7% in long-term care residents, and 29.4% in rehabilitation/sub-acute care patients, respectively [7].

It is a common assumption that aging, and diseases processes result in nutritional deficiencies unavoidably and nutritional interventions to ameliorate these deficiencies are only minimally effective [8]. However, the diversity of the causes which trigger the development of undernutrition in older adults has encouraged scientists to develop methods for early recognition of the problem. Thus, various nutritional screening tools have been developed that address different care models and different age groups in the community. Some of these screening tools query clinical and biochemical parameters (e.g., Nutritional Risk Index [NRI] and Geriatric Nutritional Risk Index [GNRI]), some of them include items about cognitive status, mobility, self-perception of nutrition, and anthropometry (e.g., long and short form of mini nutritional assessment [MNA and MNA-SF], respectively), and the others query the medical history of patients and include clinical-subjective evaluations (e.g., Subjective Global Assessment [SGA] and Nutritional Risk Screening [NRS]-2002) [9].

The MNA was proposed by some European health authorities as the first choice for nutritional assessment in home care and nursing homes [10]. Also, according to the ESPEN (European Society for Clinical Nutrition and Metabolism) guideline on clinical nutrition and hydration in geriatrics, the first stage is nutritional screening in the nutritional care process, and the MNA-SF can be preferred primarily because of its time to complete and advantages about the querying two important geriatric syndromes contributing to malnutrition development such as immobility and neuropsychological problems [11]. The MNA and MNA-SF are cost-effective, non-invasive, and useful tools [12]. Besides all these, the most validated nutritional screening tool for older adults is the MNA-SF [13]. On the other hand, another validated tool, stated in the ESPEN guidelines on definitions and terminology of clinical nutrition, was the short nutritional assessment questionnaire (SNAQ) [14]. In a review, the SNAQ, which includes no items about anthropometric and biochemical parameters, was expressed as one of the most accurate and applicable nutritional assessment tools [15]. Although the MNA-SF and SNAQ are non-invasive and useful screening tools, there is no clearly accepted diagnostic criterion for malnutrition. In some studies, multiple indexes based on nutritional screening tools have been identified as references in estimation of malnutrition, since there is no gold standard in the diagnosis of malnutrition [9,16]. In addition, representatives of several clinical nutrition socities who came together for the global leadership initiative on malnutrition (GLIM), proposed a multi-parameter method for the diagnosis of malnutrition [17]. Based on this perspective, in this paper, we aimed to evaluate the elderly home care patients in terms of malnutrition using a combined index based on different nutritional parameters (nutritional screening, anthropometric measurements, and dietary intake), and also to compare two fast and simple nutritional screening tools (MNA-SF and SNAQ) by accepting this combined index as the reference standard.

METHODOLOGY

Study Procedure

This descriptive and cross-sectional study was carried out with elderly patients (older than 65 years) who were registered to the Karaman State Hospital home healthcare unit. There were 574 patients in all ages registered to the home health services unit when the data collection started. Also, the number of elderly patients who were registered to the home health services unit was 461. We worked with the home health service unit for a period of 6 months, and we aimed to include the study all patients aged 65 years and over.

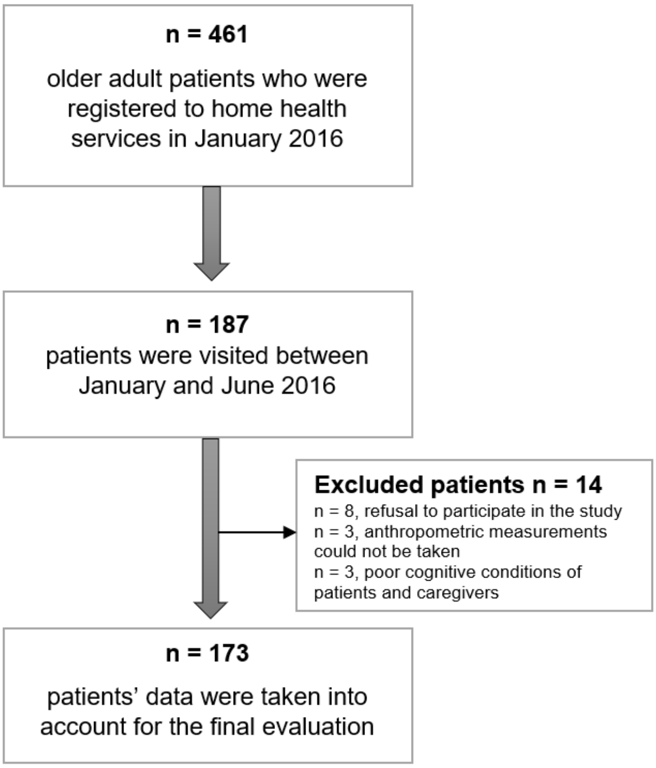

Figure 1. Flow diagram that shows the included and excluded subjects during the study (Source: Authors' own elaboration)

A total of 187 elderly patients were visited with the home health team and 179 patients or their informal caregivers (first-degree relatives) signed the informed consent form in accordance with Declaration of Helsinki protocols (World Medical Association). Patients who could not obtain accurate information from themselves and their caregivers were excluded from the study, and finally the data of 173 subjects were evaluated (**Figure 1**).

Descriptive information of the patients was obtained by a general questionnaire. Two nutritional assessment tools, MNA-SF (18) and SNAQ (19), were used to assess nutritional status. Serum albumin values measured within the last month were retrospectively recorded from the patients' medical records.

Ethical Issues

Ethical approval for the study was obtained from the Ethics Committee of Gazi University with the approval number 77082166-604.01.02. Also, a study permission letter was obtained from General Secretariat of Karaman Public Hospitals Association (Document no: 50658796/770).

Measures

Anthropometric measurements

The well-trained researchers performed the anthropometric measurements according to the measurement procedures. A non-flexible measuring tape to the nearest 0.1

cm and a calibrated electronic scale to the nearest 0.1 kg were used for the circumference and body weight measurements, respectively. The height of the participants was measured in frankfort position by a stadiometer to the nearest 0.1 cm [20]. The calculation of dividing the body weight (in kilograms) by the height (in meters) squared was considered as body mass index (BMI) (BMI = weight/height^2) [21].

The equations were used to predict the weight and height measurements of chairbound and bedridden patients. Therefore, arm circumference (AC), knee height (KH), abdominal circumference (AbC), and calf circumference (CC) were extra measured with the non-flexible measuring tape to calculate the height and weight measurements. The AC was taken from the patient's non-dominant arm (usually the left arm) at the midpoint between the olecranon and acromion, mostly in sitting posture [22]. The KH measurement was taken from the left leg with the knee and ankle each flexed to a 90° angle. The distance between the plantar surface of the foot and the anterior surface of the femoral condyle of the thigh was measured [23]. Also, the AbC was measured at the midpoint between the last rib and the upper edge of iliac crest [24]. Lastly, the sole of foot was pressed to a portable flat platform for the CC and the measurement position was set to 90° of knee flexion. The tape measure was moved up and down along the calf and the maximum measurement value was recorded [25].

The equations for height (cm) estimation [26] are, as follows:

For male = [KH (cm) × 2.08] + 59.01

For female = [KH (cm) × 1.91] - [age (year) × 0.17] + 75.00

The equation for weight (kg) estimation [27] is, as follows:

Weight = [AC (cm) × 0.4808] + [AbC (cm) × 0.5646] + [CC ×1.3160] - 42.2450

Dietary intake

The 24-hour dietary recall of patients was recorded by well-trained researchers for the assessment of daily dietary energy and protein intake. Patients and/or caregivers were asked about the portion sizes of meals and foods consumed in the last 24 hours. The "Food and Meal Photo Catalogue", a photographic atlas for Turkish foods, was used to determine portion sizes [28]. Food diaries were analysed by the nutrition information system, a food analysis software, and dietary energy and protein intakes were recorded. For dietary energy adequacy, the energy requirement and the energy reference values according to the physical activity level for adults specified in the "Turkey Dietary Guideline" [29] were considered. The recommended dietary energy values for the "5th percentile" and "low physical activity level (PAL = 1.4)" were accepted as cut-off points. These values were 1687 kcal for males aged 65-69 years, 1632 kcal for males aged 70 years and over, 1358 kcal for females aged 65-69 years, and 1310 kcal for females aged 70 years and over, respectively. Besides, for adequacy of dietary protein intake, the dietary reference intake for protein specified by the Institute of Medicine Food and Nutrition Board (0.8 g/kg/day) was accepted as the cut-off point [30].

Nutritional assessment

MNA-SF: The MNA, consisting of 18 items, was designed and validated to provide a true and rapid nutritional assessment in hospitalized older adults or nursing home residents. It is structured in four parts: global assessment (e.g., depression, dementia, medications, and living in nursing home), anthropometric assessment (e.g., BMI, calf and upper middle AC), self-assessment (e.g., mode of feeding and self-view of nutritional status), and dietary assessment (e.g., number of consumed full meals, protein, fruit, and vegetable intake) [31]. The aim of the MNA is to detect malnutrition in the early stage and to determine the need for nutritional intervention [13]. Evaluation of nutritional status has an important place in a primary care setting. However, the use of MNA in primary care settings may be disadvantageous due to its complexity and time consuming. Based on this opinion, the developers of MNA aimed to improve a short form of MNA that meets some criterions such as being highly correlated with MNA, having good diagnostic characteristics, and having high internal consistency for each item. Unnecessary items such as those requiring special training to administer, difficult subjective recalls, and too many missing or "I don't know" responses were avoided. The items poorly correlated with the full MNA score were excluded and interitem correlations were also examined. The internal consistency (alpha coefficient) was investigated using item analysis procedures. The alpha coefficients for all 18 items and alpha changes for the exclusion of an item were determined via item analysis procedures. Consecutive calculations of internal consistency were performed with the best remaining items 15, 12, 9, 6, 5, and 4. The selected six items were "recent poor intake", "recent weight loss", "neuropsychological problems", "recent psychological stress or acute disease", "mobility", and "BMI range". So, the maximum possible score of the MNA-SF is "14" and a total score less than eight classifies subjects as malnourished [18]. As an easy and fast screening tool, the MNA-SF can be used by untrained persons [32]. The multifunctional screening tool MNA-SF predicts length of hospital stay, hospitalization outcomes, physical and mental health status, and mortality [33]. Furthermore, the MNA-SF is a highly successful screening tool in predicting the risk of falling in older adults [34].

SNAQ: The Dutch health professionals determined that upon screening patients in Dutch hospitals with available tools, there were no screening tools that met the criteria recommended by the ESPEN. Therefore, they decided to develop a new screening tool according to the ESPEN screening guidelines due to the inadequate effectiveness of available screening tools. The SNAQ developed in this way was designed to be completed by a nurse [35]. It includes four questions about unintentional weight loss, appetite status, and use of supplemental drinks or tube feeding. Weight loss of more than 6 kg in the last 6 months is given a score of 3 points. Also, weight loss of more than 3 kg in the last month is given a score of 2 points. Experience of loss of appetite and use of supplemental drinks or tube feeding in the last month are also scored with 1 point each. A total SNAQ score of 3 or more indicates severe malnutrition. In contrast to the MNA and MNA-SF, the high SNAQ scores indicate malnourishment [19].

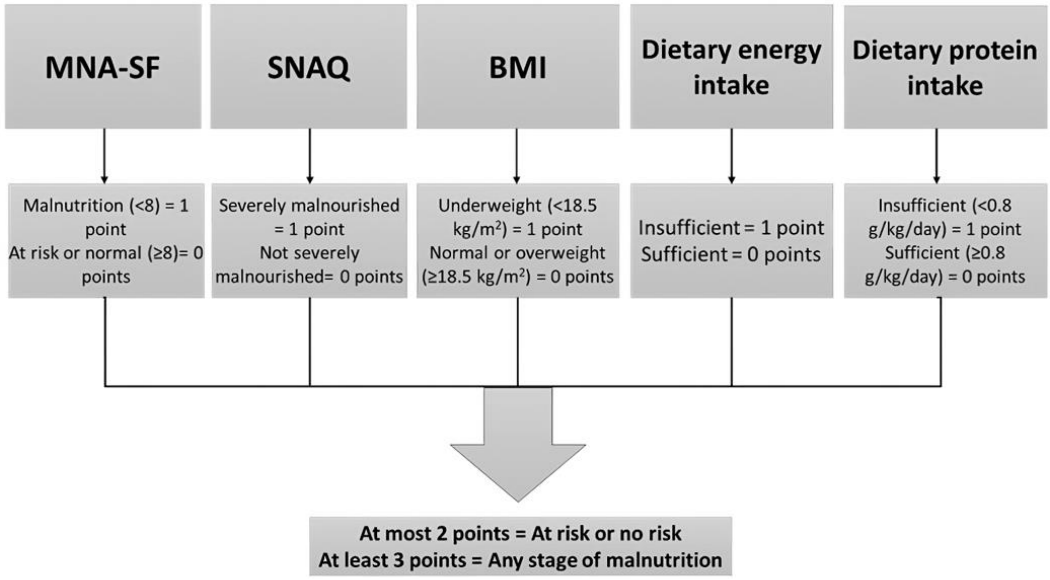

Figure 2. Combined index that derives from a merge of the results of the nutritional indexes measured (Source: Authors' own elaboration)

Table 1. General characteristics of the patients

Characteristics	n (%)	M ± SD
Gender		
Male	71 (41.0)	
Female	102 (59.0)	
Age (years)		81.6 ± 7.1
Education duration (years)		1.3 ± 2.5
Height (cm)		161.4 ± 9.4
Male		170.5 ± 4.5
Female		155.1 ± 6.2
Weight (kg)		65.5 ± 16.5
Male		66.6 ± 11.3
Female		64.7 ± 19.3
Serum albumin (g/dL)		3.3 ± 0.5
MNA-SF		7.3 ± 3.8
Malnutrition (< 8)	84 (48.6)	
At risk or normal (⩾ 8)	89 (51.4)	
SNAQ		1.7 ± 2.1
Severely malnourished	49 (28.3)	
Moderately malnourished or no intervention	124 (71.7)	
BMI (kg/m^2)		25.2 ± 6.5
Underweight (< 18.5 kg/m^2)	96 (55.5)	
Normal or overweight (⩾ 18.5 kg/m^2)	77(44.5)	
Dietary energy intake (kcal)		1,311.5 ±4 19.6
Insufficient	104 (60.1)	
Sufficient	69 (39.9)	
Dietary protein intake (g)		48.7 ± 18.4
Insufficient (< 0.8 g/kg/day)	106 (61.3)	
Sufficient (⩾ 0.8 g/kg/day)	67 (38.7)	
Combined index		
Any stage of malnutrition	82 (47.4)	
At risk or no intervention	91 (52.6)	

Note. M: Mean & SD: Standard deviation

Combined index: There is no gold standard for the assessment of nutritional status in home care patients. Therefore, the combined index was considered as a reference tool using the methodology previously suggested by Pablo et al. [36]. Nutritional status was evaluated using five nutritional parameters. For each test, negative situations (malnutrition, inadequate intake, underweight, and severely malnourished) were scored as "1" point. On the other hand, the opposite situations were scored as "0" points. If the patient had at least 3 points according to these five parameters, he/she was categorized as "any stage of malnutrition" according to the combined index classification (**Figure 2**). The combined index was considered as the criterion for true malnutrition.

Statistical Analysis

The SPSS (statistical package for the social sciences) version 20.0 was used to perform all statistical analysis. The Levene's and Kolmogorov-Smirnov tests were used to evaluate homogeneity and normality, respectively. The student's t test was used for the comparison of BMI, dietary energy and protein intake for the groups. The associations between continuous variables were evaluated with Pearson correlation coefficient. The validity coefficients (VCs) between the combined index and nutritional parameters (MNA-SF, SNAQ, BMI, dietary energy intake, and protein intake) were also calculated with Pearson correlation coefficient; then 95% confidence intervals were computed for each VC. To assess the diagnostic concordance between the nutritional parameters and combined index, Cohen's kappa coefficient (κ) values were considered. For each nutritional parameters, the sensitivity, specificity, and predictive values were calculated by considering the combined index as the standard. p-values below 0.05 were accepted as statistically significant.

RESULTS

The majority of the patients were women (59.0%), and the mean age was 81.6 ± 7.1 years (**Table 1**). Low education levels were observed, with the percentage of illiterate participants at 57.8% (not shown in tables). Also, the mean education duration was 1.3 ± 2.5 years. The mean height, weight, BMI, serum albumin, daily dietary energy intake, and protein intake values of the patients were 161.4 ± 9.4 cm, 65.5 ± 16.5 kg, 25.2 ± 6.5 kg/m^2, 3.3 ± 0.5 g/dL, 1311.5 ± 419.6 kcal, and 48.7 ± 18.4

Table 2. Correlations between nutritional parameters (MNA-SF, SNAQ, BMI, dietary energy, dietary protein, and serum albumin)

Nutritional parameters	Serum albumin		Dietary protein		Dietary energy		BMI		SNAQ	
	r**	p-value	r**	p-value	r**	p-value	r**	p-value	r**	p-value
MNA-SF	0.406	< 0.001*	0.316	< 0.001*	0.559	< 0.001*	0.531	< 0.001*	-0.857	< 0.001*
SNAQ	-0.365	< 0.001*	-0.268	< 0.001*	-0.520	< 0.001*	-0.450	< 0.001*		
BMI	0.273	0.021*	0.195	0.010*	0.322	< 0.001*				
Dietary energy intake	0.264	0.026*	0.794	< 0.001*						
Dietary protein intake	0.208	0.082								

Note. **Pearson correlation coefficient & *p < 0.05

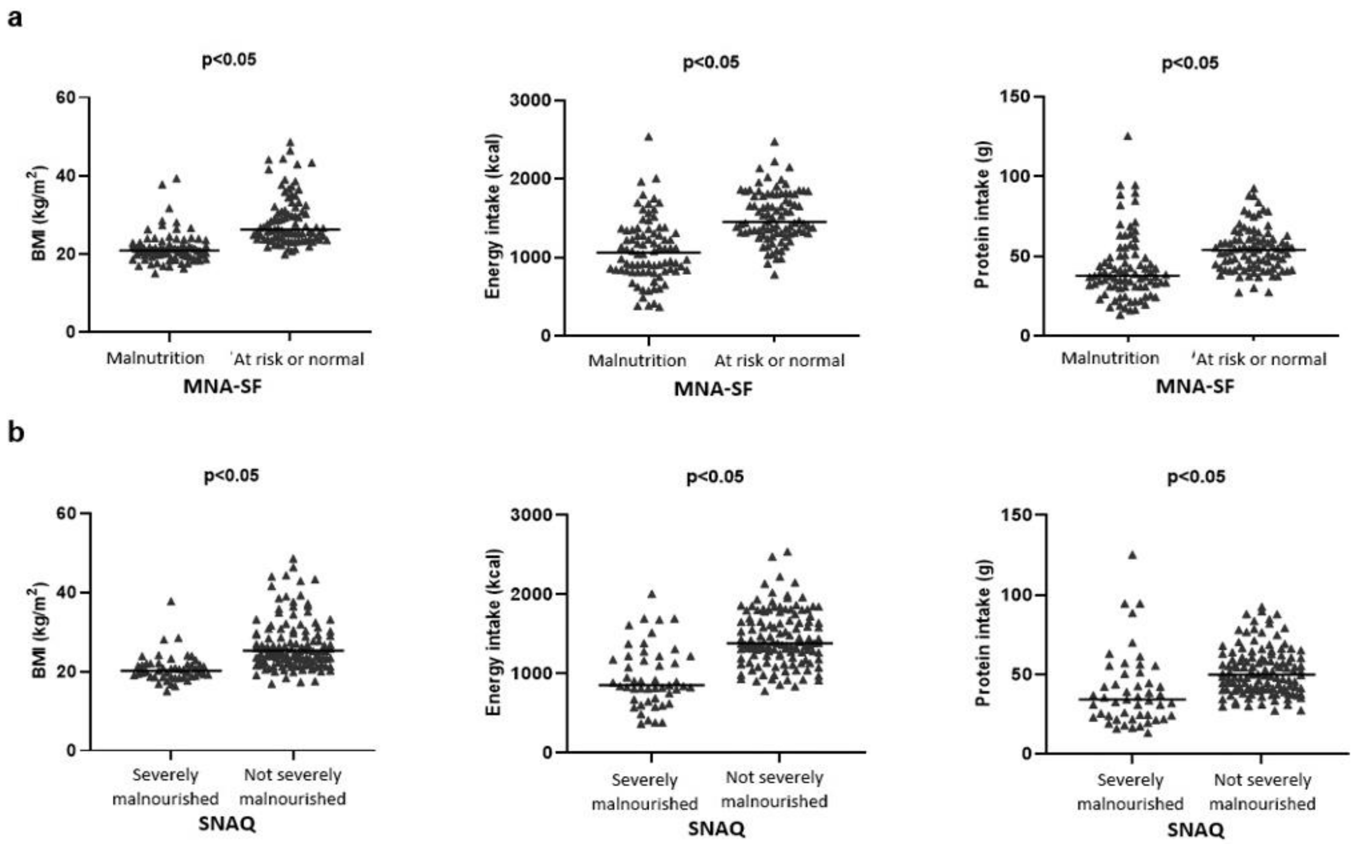

Figure 3. MNA-SF (a) and SNAQ (b) in its two outcomes, respectively, referring to BMI, dietary energy intake and dietary protein intake. Data are shown with scatterplots (Source: Authors' own elaboration, using SPSS program)

g, respectively. In addition, the mean nutritional assessment (MNA-SF and SNAQ) scores of patients were 7.3 ± 3.8 and 1.7 ± 2.1, respectively. According to the BMI values, the percentage of underweight patients was 55.5%. Furthermore, the percentages of the patients with inadequate daily dietary energy and protein intakes were 60.1% and 42.1%, respectively. The prevalence of malnutrition was 48.6% according to the MNA-SF and 47.4% according to the combined index. Besides, 28.3% of the patients were severely malnourished according to the SNAQ scores.

Pearson correlation coefficient values between all nutritional parameters are shown in **Table 2**. The MNA-SF scores were positively correlated with other nutritional parameters (serum albumin, BMI, and dietary energy and protein intakes) while the SNAQ scores were negatively correlated with them ($p < 0.05$). The highest positive correlation was found between dietary energy and dietary protein ($r = 0.794$; $p < 0.05$); whereas the highest negative correlation was found between the MNA-SF and SNAQ scores ($r = -0.857$; $p < 0.05$). There was a very strong correlation between the MNA-SF and SNAQ scores. The negative correlation was related to inverse scaling of these tests.

Figure 3 shows BMI and dietary intake (daily energy and protein) of the patients in terms of two outcomes of the MNA-SF and SNAQ. There were statistically significant differences between two outcomes of the nutritional assessment tools in terms of BMI, dietary energy intake, and protein intake ($p < 0.05$).

Table 3 shows the statistical evaluation of the efficacy of nutritional parameters according to the combined index. The sensitivity of the MNA-SF was found to be 90.2%. Having low sensitivity (59.8%), the SNAQ had the highest specificity (100.0%). In addition, the SNAQ had the highest positive predictive value (100.0%). On the other hand, the dietary energy intake was found to have the best negative predictive value (91.3%), followed by the MNA-SF (91.0%). The agreement between the combined index and nutritional parameters showed great variation. In descending order, the MNA-SF ($\kappa = 0.792$; $p < 0.001$), BMI ($\kappa = 0.632$; $p < 0.001$), dietary energy intake ($\kappa = 0.611$; $p < 0.001$), and SNAQ ($\kappa =$

Table 3. Statistical evaluation of nutritional parameters compared to the combined index

Statistical indicators	MNA-SF	SNAQ	BMI	Dietary energy	Dietary protein
Sensitivity (%)	90.2	59.8	89.0	92.7	72.0
Specificity (%)	89.0	100.0	74.7	69.2	48.4
Positive predictive value (%)	88.1	100.0	76.0	73.1	55.7
Negative predictive value (%)	91.0	73.4	88.3	91.3	65.7
κ value (p)	0.792 (< 0.001)	0.610 (< 0.001)	0.632 (< 0.001)	0.611 (< 0.001)	0.200 (0.006)
VC (95% CI)	0.792 (0.729-0.841)	0.662 (0.570-0.738)	0.641 (0.544-0.721)	0.631 (0.532-0.713)	0.208 (0.061-0.346)

Note. CI: Confidence interval

0.610; p < 0.001) had high agreement with the combined index. The VCs of the parameters revealed that the MNA-SF had the best correlation with the combined index (VC_{MNA-SF} = 0.792 [95% CI: 0.729-0.841]), followed by the SNAQ (VC_{SNAQ} = 0.662 [95% CI: 0.570-0.738]), BMI (VC_{BMI} = 0.641 [95% CI: 0.544-0.721]), and dietary energy intake ($VC_{dietary\ energy}$ = 0.631 [95% CI: 0.532-0.713]).

DISCUSSION

In January 2016, representatives from several global clinical nutrition associations convened to develop GLIM as a new diagnostic criterion for malnutrition. The GLIM working group approved a two-stage approach for the diagnosis of malnutrition; first stage was screening individuals to identify "malnutrition risk" by using validated screening tool, and the second was grading the severity of malnutrition. For the second step, GLIM working group members voted on some potential criteria. The most voted five criteria were "non-volitional weight loss", "low BMI", "reduced muscle mass", "reduced food intake or assimilation", and "inflammation or disease burden" [17]. Similar to the GLIM criteria, the combined index that we used to determine true malnutrition was based on more than one nutritional parameter. We are in the opinion that it is necessary to discuss the use of a diagnosis and evaluation method consisting of multiple parameters including screening tools instead of the use of a single assessment tool.

It is noteworthy that the mean dietary energy and protein intakes of the participants in the present study were quite low. The mean MNA-SF and SNAQ scores were also very low. So, the proportion of malnourished patients was quite high. According to the MNA-SF scores, 48.6% of the patients were malnourished. The MNA-SF was found to show a higher prevalence of malnutrition as compared to the SNAQ (28.3%). Similar results have been reported in recent studies [37-39]. It was reported that the prevalence of nutritional risk was 27.9% according to the NRS-2002, 39.6% according to the MUST, and 73.2% according to the MNA-SF [37]. It was assessed 83 older adults in a geriatric hospital, reported that 63.9% of patients were at nutritional risk according to the MNA-SF [38]. In another study conducted with 259 elderly patients, the percentage of nutritional risk was found to be 81.5% using the MNA-SF [39]. Different malnutrition prevalence indicated by the MNA-SF and SNAQ potentially could be due to their different scoring systems. As mentioned before, the MNA-SF is based on six items and a score less than eight out of fourteen is considered malnutrition. On the other hand, a subject must have a history of major weight loss, such as more than 6 kg in the last 6 months or more than 3 kg in the last month, in order to be classified as "severely malnourished" according to the SNAQ. We can state that this is the main reason why the SNAQ showed a lower prevalence of malnutrition as compared to the MNA-SF.

The high correlation between nutritional assessment tools and important nutritional parameters, such as serum albumin and BMI suggests that these nutritional assessment tools are very sensitive to changes in clinical and anthropometric outcomes. There are similar results in the literature, especially about the relationship between nutritional parameters and the MNA/MNA-SF [32, 40-43]. It wasreported a high correlation (r = 0.78) between the MNA-SF and BMI in a community-dwelling elderly population [40]. It was reported a significant positive correlation between the MNA-SF and BMI in a study on elderly patients that had undergone operations for hip fracture [32]. It was also reported that MNA-SF was positively correlated with both BMI (r = 0.57) and serum albumin (r = 0.56) in a frail elderly Japanese population [41]. In a study comparing the MNA, SGA, and NRS-2002 in geriatric hospitalized patients, only the MNA was reported to be positively associated with the serum albumin values of the participants [42]. Another study comparing the MNA and NRS-2002 in geriatric hospitalized patients reported that a statistically significant difference was observed between the MNA groups in terms of serum albumin levels, whereas there was no significant difference between the NRS-2002 groups [43].

The correlation coefficients between the nutritional parameters showed great variation. The highest positive correlation was found between dietary energy and dietary protein (r = 0.794), followed by dietary energy and MNA-SF (r = 0.559). In addition, the highest negative correlation was found between the MNA-SF and SNAQ (r = -0.857). So, we consider that the MNA-SF, shown previously to be highly correlated with the MNA [18, 42], may be eligible for elderly home care patients, as it is fast and simple. In studies comparing the nutritional screening/assessment tools in older adults, the MNA and MNA-SF were found to be better than other tools in predicting the clinical outcomes and 12-month mortality rates [44, 45]. Also, the ESPEN has recommended the MNA as the first choice for assessing the nutritional status in older adults [46]. On the other hand, the MNA-SF has been reported to be a slightly better predictor than the MNA in a study on the prediction of perceived health by nutritional indicators [47].

There were statistically significant differences between the two MNA-SF groups ("malnutrition" and "at risk or normal") with regard to BMI, dietary energy, and dietary protein intake. Furthermore, statistically significant differences were observed between the two SNAQ groups ("severely malnourished" and "moderately malnourished or no intervention") with regard to the same nutritional parameters (**Figure 3**). Similarly, there were results that support the present findings in other studies [48, 49]. So it is clear that the outcomes of these two assessment tools are sensitive to nutritional parameters such as BMI, dietary energy, and dietary protein.

Since there is no gold standard for the assessment of the nutritional status in elderly home care patients, the combined index was developed as a reference tool to determine the sensitivity, specificity, positive and negative predictive values, κ, and VC of all nutritional parameters. The MNA-SF has a sensitivity of 90.2% compared to the combined index. In addition, the specificity values of the SNAQ and MNA-SF were 100.0% and 89.0%, respectively. The results of many studies on the statistical evaluation of the MNA and MNA-SF according to the chosen reference standard are similar to the results of this study [9, 16, 50]. Baek and Heo [16] compared five screening and assessment tools (MNA, MNA-SF, GNRI, MUST, and NRS-2002) to estimate malnutrition in older subjects and classified a subject as malnourished according to the combined index if the subject was assessed as undernourished according to at least four out of these five tools. Similar to the results of the present study, the MNA and MNA-SF were found to have the highest sensitivity. In addition, the inter-rater agreement (kappa) between the MNA-SF and combined index was statistically significant. In a study comparing six nutritional screening and assessment tools (MNA-SF, MUST, NRS-2002, NRI, GNRI, and SGA), subjects were assessed as malnourished according to the combined index if they were at risk of malnutrition according to at least four screening/assessment tools. The sensitivity of the MNA-SF compared to the combined index was found to be 98.1%. Also, the kappa and VC values of the MNA-SF were reported to be quite high [9]. In another study, older adults with a BMI ≤ 20 kg/m^2 and severe unintentional weight loss (more than 5% in the last month or more than 10% in the last 6 months) were defined as severely malnourished. So, this classification was accepted as the reference assessment. The MUST, NRS-2002, and MNA-SF were compared according to this reference assessment and similar to the present study, the MNA-SF was reported to have the highest sensitivity and negative predictive value [50]. From this perspective, the findings of the present study and the results of all these studies may be evidence for the high sensitivity and eligibility of the MNA-SF in the assessment of nutritional status in older adult patients and community-dwelling older adults.

The four-item SNAQ includes much more serious conditions for the definition of severe malnutrition, such as severe unintentional weight loss, extreme appetite loss or tube feeding. In this study, all severely malnourished subjects according to the SNAQ were also found to be malnourished according to the MNA-SF and combined index (not shown in tables). That is why the SNAQ had the highest specificity (100.0%) in this study. Compared to the MNA and MNA-SF, the SNAQ has the advantages of being faster and simpler and not involving any anthropometric measurements. However, the SNAQ is thought to be weaker than the MNA and MNA-SF in predicting "malnutrition risk".

CONCLUSIONS

In order to prevent and treat malnutrition and hence enhance quality of life, it is critical to assess the nutritional status of home care patients. The findings suggest that malnutrition in elderly home care patients can be effectively diagnosed with the use of a combined index that is based on both screening tools (MNA-SF and SNAQ) and other nutritional parameters (dietary intake and anthropometric measurements). However, a professional team may be required for detailed analysis of some components of the combined index (e.g., dietary intake). Therefore, we believe that a multidisciplinary team, including nutritionists, is a sine qua non for effective and holistic home health care service.

Author contributions: EA: conceptualization, data curation, investigation, methodology, writing-original draft preparation, & statistical analysis & **NA-T:** methodology, writing-original draft preparation, & supervision. Both authors agree with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgments: The authors would like to thank the participants for their valuable time.

Declaration of interest: No conflict of interest is declared by the authors.

Ethical statement: The authors stated that the study was approved by the Ethics Committee of Gazi University on 18 January 2016 with the approval number 77082166-604.01.02. Written informed consents were obtained from the participants.

Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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