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ORIGINAL ARTICLE

Geriatric nutritional risk index as a simple tool for assessment of malnutrition among geriatrics in Northwest of Iran: comparison with mini nutritional assessment

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Abstract

Background Older people are more likely to develop nutritional problems and timely diagnosis of malnutrition is crucial to prevent hazardous consequences following poor nutrition.

Aims To evaluate the efficacy of Geriatric Nutritional Risk Index (GNRI) to assess nutritional status among non-hospitalized elderly, compared to mini nutritional assessment (MNA) among Iranian seniors.

Methods One hundred and sixty-four subjects, aged ≥ 65 years old were recruited to our cross-sectional study from various districts of Tabriz (Tabriz, Iran). Anthropometric and biochemical measurements were performed, short- and long-form MNAs and GNRI were assessed in our study subjects. Sensitivity, specificity and predictive values of the three indices, agreement between them, and their correlation with anthropometric and biochemical parameters were evaluated. Receiver-operating characteristic (ROC) curve analysis was performed to determine the optimal cut-off point for GNRI in our study population.

Results GNRI had lower sensitivity (50, 57%), but optimal specificity (94, 93%) and lower negative predictive value (NPV; 68, 71%) compared to MNA-LF and MNA-SF, respectively. We found a moderate agreement between GNRI and MNA-SF ($K = 0.52$) and MNA-LF ($K = 0.46$) scores. Significant correlations were observed between re-categorized MNAs as well as GNRI scores, and age, weight, MAC, CC, WC, albumin, and pre-albumin. The cut-off point of 110.33 was obtained for GNRI, according to the ROC curve.

Conclusions Although GNRI may not be an efficient tool for screening malnutrition due to its lower sensitivity, it is moderately correlated with MNAs and also more useful when limited funding needs to target the truly malnourished seniors.

Keywords Elderly · Geriatric Nutritional Risk Index (GNRI) · Mini nutritional assessment (MNA) · Sensitivity · Specificity

Introduction

Aging has become a global concern due to its rapid growth; it is predicted that the number of the elderly will triple by the year 2050 compared to 2000 [1]. Iran is not an exception from this graying process of the world, and is estimated to experience an "Aging Tsunami" by 2046, its senior population increasing from the current 8.2–22% in that year [2]. This aging population with particular requirements demands special social infrastructures and welfare [3]; improved healthcare systems including appropriate nutritional assessments, which can lead to prompt and relevant interventions, are amongst the most important factors to take into account, in this regard.

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Good nutrition is critical for healthy aging [4]; older people are more likely to develop nutritional problems due to altered function of gastrointestinal system, chronic diseases, polypharmacy, loneliness, depression, poor oral hygiene, and recurrent admissions [5–7]. Protein-energy malnutrition (PEM) has been reported to have an approximate prevalence of 20–78% among the elderly worldwide; in Iran, malnutrition was found to be the leading health issue suffered by the elderly, with a prevalence of 68.3% [8]. Malnutrition in the elderly results in higher mortality rate, increased risk of infections, and admissions [9]. It is noteworthy that malnutrition usually remains undiagnosed in older people, since its symptoms are very similar to the changes accompanying the aging process [10].

Studies have shown that timely diagnosis of malnutrition and subsequent proper nutritional care in these seniors is crucial to the improvement of their current health problems and their prognosis as well as prevention of some hazardous consequences following poor nutrition [11–15]. There are many methods for assessment of nutritional status in the elderly; mini nutritional assessment (MNA), recommended by the European Society of Parenteral and Enteral Nutrition (ESPEN) is the most widely used assessment which identifies the malnourished and at risk elderly. Validity and reliability of the translated MNA questionnaire have been confirmed by the studies conducted in Iran [16–18]. However, this assessment is not applicable in those who have communication or functional problems, or memory loss; also, its application requires close cooperation of the elderly to complete the MNA forms correctly [19]. Due to these shortages, Geriatric Nutritional Risk Index (GNRI) which is a new "prognostic index of nutritional status-related complications" was developed to be applied in hospital settings. Since GNRI has been shown to have significant correlations with anthropometric and biochemical measures, it is lately adopted in non-institutionalized subjects, along with MNA, to assess nutritional status as well [20–22]. Most geriatrics give regular blood tests as required by their physicians to monitor their blood sugar or lipids; this means that GNRI calculation should not be regarded as an invasive and thus unethical means of nutritional assessment. It facilitates diagnosis of malnutrition using the same blood sample provided for the other checkups.

To the best of our knowledge, no study in Iran has used GNRI to assess nutritional status of non-hospitalized elderly. Therefore, the aim of the present study was to evaluate the efficacy of GNRI to detect malnutrition in non-hospitalized elderly living in Northwest of Iran, in comparison with a well-validated tool, MNA (both its long and short forms)—Persian versions (MNA-LF and MNA-SF).

Materials and methods

Participants

This cross-sectional study was conducted between April 2015 and June 2015, on the elderly residing in Tabriz, IR. Iran. One hundred and sixty-four subjects aged ≥ 65 years old were recruited to the study from various settings in Tabriz (mosques, parks, organizations offering activities for older people, and advertisements) based on the following criteria: willingness and capability to participate in the study. The exclusion criteria were affliction with severe physical or mental illnesses, diagnosis of end-stage liver or kidney diseases, edema, varicosis, chronic inflammatory diseases and amputations, smoking or drinking alcoholic beverages.

Study procedures

Demographic characteristics of the subjects were obtained through a face-to-face interview and studying medical records. Anthropometric measurements including weight, height, mid-arm circumference (MAC), calf circumference (CC) and waist circumference (WC) were performed according to the standard protocols, in the morning and after urinating, with the least clothes and no shoes on. Standing height of the elderly was measured by a tape to the nearest 0.1 cm; if a subject could not stand straight, a sliding broad-blade caliper (Ross Laboratories, OH, USA) was used to measure knee height (KH) to the nearest 0.1 cm and estimate the height, using the following equations taken from Chumlea et al. [23]:

$$\text{For men}: H(\text{cm}) = [2.02 \times KH(\text{cm})] - \left[0.04 \times \text{age}(y)\right] + 64.19 \quad (1)$$

$$\text{For women}: H(\text{cm}) = [1.83 \times KH(\text{cm})] - \left[0.24 \times \text{age}(y)\right] + 84.88. \quad (2)$$

Body mass index (BMI) was calculated as weight (Kg) divided by squared height (m^2). Weight was measured by a calibrated Seca scale (Seca, Germany) with the precision of 0.1 Kg. Ideal body weight (Kg) was calculated using the Lorentz equation (WLo) [24]:

$$\text{Ideal Body Weight (males)} = \text{Height} - 100 - ((\text{height} - 150)/4) \quad (3)$$

$$\text{Ideal Body Weight (females)} = \text{Height} - 100 - ((\text{height} - 150)/2.5). \quad (4)$$

A metric tape with a precision of 0.1 cm was used to measure MAC (at the mid-point between acromion process of scapula and olecranon process), CC (at the level of the largest circumference of the left calf of the subject

while sitting on a chair with his legs hanging, or at supine position with the leg bent at 90°) and WC (at mid-point between the lowest rib and the hip bone).

To perform biochemical assays, 5 ml of blood was drawn between 7:00–8:00 AM, after a 12-h-overnight fast at supine position. The sera of the blood samples were obtained by centrifugation at 3500 rpm for 10 min at room temperature, and frozen at − 80 °C until assay. Albumin was measured using the standard enzymatic colorimetric method by commercial kits (Pars Azmoon Inc., Tehran, Iran) with a Hitachi 917 autoanalyser, Japan (CV inter-assay: < 0.1%). Enzyme-linked immunosorbent assay (ELISA) was used to quantify high sensitivity C-reactive protein (hs-CRP) concentrations using commercial kits (Monobind Inc., USA). Pre-albumin was analyzed using nephelometry by the Minineph ™ Human kits (Birmingham, UK).

Dietary intakes of the study participants were assessed by 3-day food records (two working days and 1 weekend). Subjects or their care givers were provided with necessary instructions on household measures, portion sizes and how to fill in the forms, prior to the commencement of the study. Moreover, a small food scale was handed over to allow for weighing of the foods consumed. A second visit was arranged by a trained dietitian to check for the accuracy and completeness of the information recorded. Dietary intakes of the elderly were converted to grams and subsequently analyzed using Nutritionist IV (Axxya Systems, Stafford, TX) software.

MNA-Short Form (MNA-SF) was completed for the participants and the scores were categorized as follows: malnutrition (< 7), at risk for malnutrition (8–12) and good nutrition (12–14) [25]. The translated and validated Persian form [26] of MNA-Long Form (MNA-LF) [19] questionnaire was also used to classify nutritional status of the elderly; scores lower than 17 were indicative of "malnutrition", scores 17–23.5 showed the state "at risk of malnutrition", and subjects who had scores higher than 24 were considered "well-nourished".

GNRI was calculated for the participant using the equation below [24]:

$$\mathrm{GNRI} = \left[1.489 \times \mathrm{Albumin\ (g/L)}\right] + \left[41.7 \times (\mathrm{weight/WLo})\right] \quad (5)$$

Nutritional risk categories are originally defined as: severe risk (GNRI < 82), moderate risk GNRI: 82–92, low risk (GNRI: 92–98); no risk (GNRI > 98) [20]. Based on these original cut-off points for GNRI, all the patients fell into either "no risk" or "low risk" categories in our study population, therefore, we needed to determine a new cut-off point to more properly discriminate between the subjects with varying degrees of malnutrition risk.

Statistical analyses

To check for the normality of the data distribution, the Kolmogorov–Smirnov test and histograms were used. Data were expressed as frequency (%) for categorical variables and mean (standard deviation, SD) for continuous variables. Chi-square test or Fisher's exact test was used to compare categorical data. Independent samples t test or Mann–Withney U test was performed to determine the significance of differences between groups, as appropriate. Correlations between two quantitative variables were also carried out using Pearson's or Spearman's correlation coefficient tests. The area under the receiver operating curve (ROC) analysis was performed to calculate the cut-off value of GNRI, based on MNA-LF. The internal validity of GNRI to predict malnutrition was determined by calculating the sensitivity and specificity, and the external validity was calculated by positive predictive value (PPV) and negative predictive value (NPV). The cut-off points of validity were set as proposed by Van Bokhorst-de van der Schueren MA et al. [27]: sensitivity and specificity > 80%, good validity; sensitivity or specificity < 80% but both > 50%, fair validity; sensitivity or specificity < 50%, poor validity.

The agreement of GNRI with both MNAs was determined with kappa test (κ) statistics. The cut-off points of reliability were set as suggested by Landis and Koch [28]: κ:< 0, no agreement; 0.00–0.20, poor agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and 0.81–1.00, almost perfect agreement. We utilized the new cut-off point for GNRI, obtained from the ROC analysis as "malnourished/ at risk for malnutrition" and "well-nourished". We re-categorized both MNA scores as for GNRI, using their own international cut-offs (score of 12 for MNA-SF and score of 24 for MNA-LF; the other two categories of each tool were merged). SPSS for Windows ver.17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. All primary hypotheses were examined using two-tailed tests with a 0.05 significance level.

Ethics

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the ethics committee of Tabriz University of Medical Sciences (Ethics code: TBZMED.REC.1394.24). Written informed consent was obtained from all subjects.

Results

The study consisted of 104 (63.4%) women and 60 (36.6%) men, aged ≥ 65 years old (mean = 73.99 years), residing in Tabriz, Northwest of Iran. Table 1 presents the

Table 1 Characteristics of the study participants

Variables	Study participants ($n=164$) Mean (SD)
Age (years)	73.99 (8.30)
Sex (female), *n* (%)	104 (63.41)
Weight (Kg)	65.24 (15.45)
WLo (Kg)	54.58 (7.62)
Weight/WLo	1.20 (0.26)
Height (cm)	147.56 (9.76)
BMI (Kg/m^2)	26.74 (5.85)
MAC (cm)	28.66 (4.01)
CC (cm)	33.38 (5.22)
WC (cm)	94.99 (13.64)
hs-CRP (mg/L)	5.61 (2.30, 13.56)
Albumin (g/L)	40.54 (4.62)
Pre-albumin (mg/dl)	0.018 (0.07)
MNA-SF score	12.03 (2.39)
MNA-LF score	25.61 (3.44)
GNRI score	110.91 (13.88)
Weight loss during last 6 months, *n* (%)	20 (12.19)
Poor appetite, *n* (%)	20 (12.19)
Calorie intake	1263.33 (399.73)
Protein intake	49.39 (18.30)
Fat intake	29.09 (11.25)
Carbohydrate intake	204.74 (74.36)

WLo Lorenz weight, *BMI* body mass index, *MAC* mid-arm circumference, *CC* calf circumference, *WC* waist circumference, *hs-CRP* high sensitivity C-reactive protein, *MNA-SF* mini nutritional assessment-short form, *MNA-LF* mini nutritional assessment-long form, GNRI Geriatric Nutritional Risk Index

characteristics of the study participants. Forty-five subjects (27.4%) aged 65–74 years old, 64 (39.0%) were 68–77 years old, and 55 (35.5%) had 78–95 years of age. Only 20 subjects (12.2%) had diploma or higher educational statuses; others were either illiterate or undergraduate. The majority of the elderly in our study were home-maids, unemployed or workers (71.3%), retired teachers or employees and self-employed, making up the rest of the study population. Among the study subjects, 20.1% had diabetes, 3.0% were diagnosed with chronic obstructive pulmonary disease (COPD), and 40.9% were afflicted by cardiovascular diseases. Oral diseases, gastrointestinal disorders, osteoporosis and osteoarthritis affected 2.5, 12.8, 3.1 and 16.0% of the subjects, respectively. Depression was observed in 11% of the participants. 22.2% of the women and 21.1% of the men had anemia. As obtained from the data produced by Nutritionist IV, the study subjects consumed approximately 60% (62.34 ± 18.30) of the RDA for their caloric needs (calculated based on the individuals' age and sex) on average, and 57.1% of them had protein intakes lower than the RDA (0.8 gr/Kg).

Figure 1 presents the prevalence of malnutrition based on GNRI, MNA-SF, and MNA-LF in our population. GNRI scores were re-categorized into three subgroups: no risk, low–medium risk, and high risk, for better comparison between the three indices.

As mentioned in research method, the three assessment tools were re-categorized into two classes. Re-categorized MNA-SF and MNA-LF revealed that 67.1 and 72% of the subjects were well-nourished, respectively; between-sex differences were only significant for the latter ($p=0.032$). Based on ROC curve analysis, the score of 110.33 was obtained as the cut-off point for GNRI in our study (Fig. 2). Based on this cut-off point, 53.2% of the subjects were well-nourished, and between-sex differences remained insignificant ($p=0.104$).

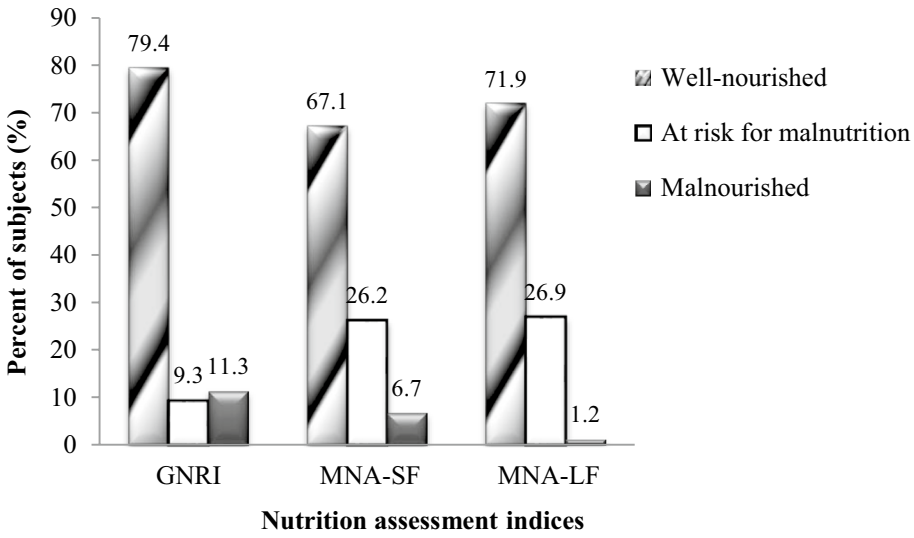

Fig. 1 Prevalence of malnutrition (%) based on GNRI, MNA-SF and MNA-LF scores. *GNRI* Geriatric Nutritional Risk Index, *MNA-LF* mini nutritional assessment-long form; MNA-SF, mini nutritional assessment-short form

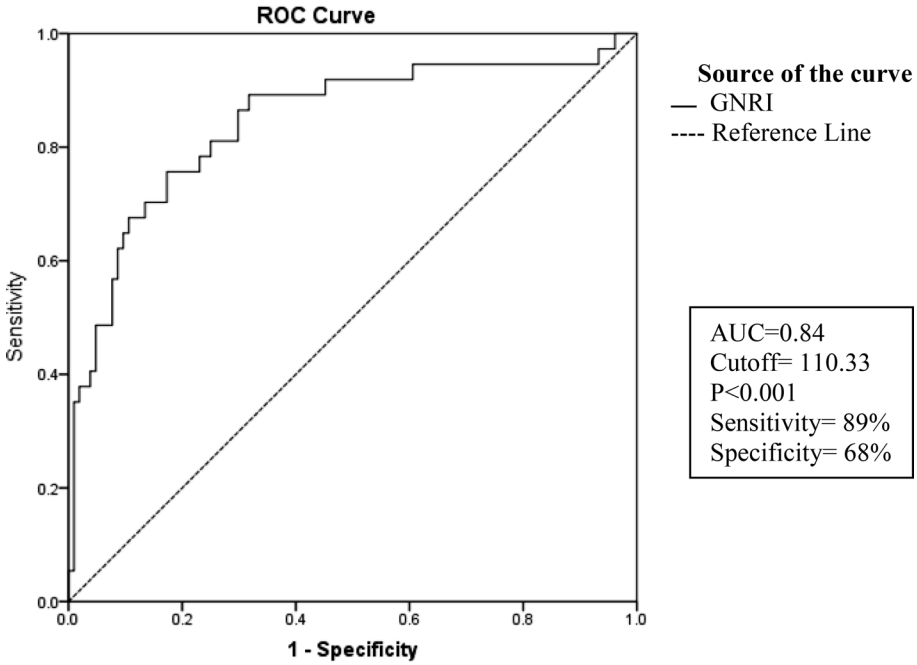

Fig. 2 Receiver operating curve (ROC) analysis to examine a cut-off value of GNRI, compared to MNA-LF. *GNRI* Geriatric Nutritional Risk Index, *MNA-LF* mini nutritional assessment-long form

Table 2 presents either mean (SD) or median (percentiles 25, 75) for age, anthropometric and biochemical variables as well as MNA-SF, MNA-LF, and GNRI scores within each subgroup of the nutritional assessment indices; correlations between the above-mentioned parameters and the nutritional indices are also shown. Subjects in the two classification of the re-categorized GNRI were significantly different in terms of age, weight, WLo, weight/WLo, BMI, MAC, CC, WC, albumin, pre-albumin, and MNA-LF as well as GNRI scores; however, the differences in WLo, hs-CRP, and calorie intake were not significant between the two groups. Similar results were obtained in case of re-categorized MNA-LF and MNA-SF. Except for hs-CRP and calorie intake, significant correlations were found between the above-mentioned parameters and MNA-SF, MNA-LF, and GNRI. Age had a negative moderate correlation with GNRI ($r = -0.333$, $p < 0.001$), while it showed only a weak correlation with MNA-SF and MNA-LF.

Among the three indices, GNRI had the strongest correlation with body weight ($r = 0.765$) and BMI ($r = 0.877$); Albumin and pre-albumin also had a stronger correlation with GNRI, compared to MNA-SF and MNA-LF. These two latter indices had a strong positive correlation with each other ($r = 0.905$), but a moderate correlation with GNRI ($r = 0.617$ and $r = 0.650$, respectively, $p < 0.001$ for both).

GNRI had a very high specificity, but fair sensitivity, compared to MNA-LF and MNA-SF (Table 3). Likewise, GNRI had lower NPV, decreasing likelihood of mistaken classification of well-nourished subjects as malnourished. A moderate agreement of GNRI was also found with MNA-SF (K value = 0.52) and MNA-LF ($K = 0.46$; Table 3).

Discussion

In the present cross-sectional study, GNRI was found to have moderate agreement with MNA-SF and MNA-LF. We defined a new cut-off point (110.33) for GNRI in our study population, based on MNA-LF; we also found significant correlations of re-categorized MNAs as well as GNRI with age, weight, MAC, CC, WC, albumin, and pre-albumin. Moreover, the three indices correlated well with each other.

Although we observed a significant correlation between GNRI and MNA scores, the agreement between these scores was only moderate in our subjects. These discrepancies were also reflected in the prevalence of malnutrition among the participants as assessed by the three indices; GNRI was found to classify less elderly as being malnourished. Our finding was in agreement with that of Abd-El-Gawad et al. [29] who reported much lower kappa values ($K \approx 20\%$ and $K \approx 10\%$ for MNA-LF and MNA-SF, respectively) despite the moderate correlations between GNRI and the two MNAs. MNA was more likely to detect subnormal nutritional status in subjects, when compared to GNRI, as presented by sensitivity value. Similar results were also obtained by Cereda et al. [30] and Alert et al. [10].

In our investigation, GNRI had lower sensitivity, but optimal specificity, compared to both MNA results. GNRI is an adaptation of NRI in seniors [31] and a previous study showed that NRI had low sensitivity (43.1%), but high specificity (89.3%) [32]. Another research reported the sensitivity and specificity of GNRI to be low (66.0%) and high (92.1%), respectively, as well [31], which indicated lower screening power of malnutrition by GNRI. Kang et al. [33] also found

Table 2 Comparison of the scores for different patients' characteristics, anthropometric and laboratory measures, between MNA-SF, MNA-LF and GNRI categories, and their correlations

Parameters	MNA-SF				MNA-LF				GNRI			
	Well-nourished	At risk or malnourished	*P*	*r* *P*	Well-nourished	At risk or malnourished	*P*	*r* *P*	No risk	At risk or malnourished	*P*	*r* *P*
Age (years)	72.87 (7.91)	76.28 (8.69)	0.013	− 0.225 0.004	72.96 (8.02)	76.65 (8.51)	0.010	− 0.298 < 0.001	71.47 (71.20)	76.38 (8.34)	< 0.001	− 0.333 < 0.001
Weight (Kg)	70.48 (13.55)	53.44 (12.83)	< 0.001	0.549 < 0.001	69.45 (13.72)	53.02 (13.70)	< 0.001	0.566 < 0.001	74.62 (13.06)	55.11 (11.90)	< 0.001	0.765 < 0.001
WLo (Kg)	55.40 (7.40)	52.93 (7.88)	0.053	0.157 0.047	55.42 (7.62)	52.51 (7.30)	0.029	0.209 0.008	54.57 (7.48)	54.82 (7.67)	0.843	− 0.071 0.403
Weight/WLo	1.28 (0.22)	1.01 (0.24)	< 0.001	0.512 < 0.001	1.26 (0.23)	1.01 (0.26)	< 0.001	0.513 < 0.001	1.37 (0.20)	1.00 (0.19)	< 0.001	0.876 < 0.001
BMI (Kg/m^2)	28.57 (4.97)	22.61 (5.61)	< 0.001	0.514 < 0.001	28.22 (5.10)	22.55 (5.84)	< 0.001	0.516 < 0.001	30.60 (4.50)	22.50 (4.23)	< 0.001	0.877 < 0.001
MAC (cm)	30.22 (3.21)	25.48 (3.60)	< 0.001	0.605 < 0.001	30.00 (3.30)	25.21 (3.63)	< 0.001	0.624 < 0.001	30.98 (2.95)	26.56 (3.63)	< 0.001	0.721 < 0.001
CC (cm)	35.36 (4.57)	29.31 (3.99)	< 0.001	0.594 < 0.001	35.21 (4.43)	28.77 (4.13)	< 0.001	0.621 < 0.001	35.68 (4.65)	31.33 (4.76)	< 0.001	0.586 < 0.001
WC (cm)	99.13 (12.20)	84.38 (11.32)	< 0.001	0.537 < 0.001	98.18 (12.71)	84.60 (11.30)	< 0.001	0.514 < 0.001	102.11 (12.90)	87.97 (10.30)	< 0.001	0.689 < 0.001
hs-CRP (mg/L)*	5.54 (2.43, 13.11)	6.13 (1.48, 18.15)	0.995[a]	0.039 0.631[b]	5.37 (2.38, 12.77)	6.66 (2.01, 17.54)	0.505[a]	0.017 0.833[b]	6.99 (2.97, 14.75)	4.70 (2.02, 12.80)	0.187[a]	0.090 0.288[b]
Albumin (g/L)	41.60 (4.30)	38.30 (4.53)	< 0.001	0.403 < 0.001	41.52 (4.35)	37.95 (4.36)	< 0.001	0.422 < 0.001	43.01 (3.05)	38.25 (4.64)	< 0.001	0.594 < 0.001
Pre-albumin (mg/dl)	0.20 (0.07)	0.15 (0.05)	< 0.001	0.420 < 0.001	0.20 (0.07)	0.15 (0.05)	< 0.001	0.418 < 0.001	0.21 (0.06)	0.16 (0.06)	< 0.001	0.450 < 0.001
Energy intake (kcal/day)	1297.8 (430.0)	1183.1 (307.8)	0.065	0.149 0.067	1297.7 (423.5)	1172.4 (315.4)	0.050	0.158 0.050	1287.4 (395.9)	1276.8 (415.5)	0.881	0.065 0.454
MNA-SF score	13.47 (0.77)	9.11 (1.82)	< 0.001	–	13.17 (1.23)	9.10 (2.14)	< 0.001	0.905 < 0.001	13.40 (1.20)	10.74 (2.63)	< 0.001	0.617 < 0.001
MNA-LF score	27.50 (1.66)	21.76 (2.90)	< 0.001	0.905 < 0.001	27.40 (1.60)	21.01 (2.51)	< 0.001	–	27.52 (1.77)	23.80 (3.67)	< 0.001	0.650 < 0.001
GNRI score	115.91 (11.19)	99.50 (12.70)	< 0.001	0.617 < 0.001	115.37 (11.22)	98.35 (13.02)	< 0.001	0.650 < 0.001	121.38 (7.64)	99.01 (8.85)	< 0.001	–

WLo Lorenz weight, *BMI* body mass index, *MAC* mid-arm circumference, *CC* calf circumference, *WC* waist circumference, *hs-CRP* high sensitivity C-reactive protein, *MNA-SF* mini nutritional assessment-short form, *MNA-LF* mini nutritional assessment-long form, *GNRI* geriatric nutritional risk index

[a]Mann–Whitney U test; all other between-category comparisons were performed by two samples t test

[b]Spearman's correlation test; all other correlation tests were performed by Pearson's correlation test

*Median (percentiles 25 and 75); all other measures are presented as mean (SD)

Table 3 Statistical evaluation of the GNRI score compared to MNA-LF and MNA-SF scores

	MNA-LF	MNA-SF
Sensitivity (95% CI)	0.50 (0.38–0.61)	0.57 (0.45–0.68)
Specificity (95% CI)	0.94 (0.87–0.97)	0.93 (0.85–0.97)
PPV (95% CI)	0.89 (0.75–0.95)	0.88 (0.75–0.94)
NPV (95% CI)	0.68 (0.58–0.76)	0.71 (0.62–0.80)
Kappa value (SE)	0.46 (0.06)	0.52 (0.06)

GNRI Geriatric Nutritional Risk Index, *MNA-LF* mini nutritional assessment-long form, *MNA-SF* mini nutritional assessment-short form, *PPV* positive predictive value, *NPV* negative predictive value

a lower sensitivity (54.5–68.0%) and relatively higher specificity (67.7–71.1%) for GNRI in their study. Our results were in accord with these studies and may lead us to conclude that according to lower NPV, GNRI may be more useful tool for nutritional assessment in cases of restricted funding sources; however, this should be noted with caution since the standard method used to validate GNRI was different among the aforementioned studies and may impact our judgment about the most applicable tool in a target population. For instance, Baek et al. [34] reported a high sensitivity (95.2%) and moderate specificity (67.1%) for GNRI using a combined index as the standard tool for nutritional assessment; compared to this index, MNA had higher sensitivity (100%) than GNRI in detecting malnourished elderly.

As mentioned above, a new cut-off point (110.33) was used for GNRI among our study participants according to ROC analysis. Some studies have also applied GNRI cut-off points other than the original ones, with regard to their study aims [33, 35]. Although MNA is a useful tool for assessment of malnutrition among the elderly, it cannot be regarded as gold standard for nutritional diagnosis in these subjects [36]. In addition, it was shown to have low specificity, despite its high sensitivity, leading to overestimation of malnutrition rate among the elderly [37, 38]. Moreover, GNRI had low sensitivity in detecting those with malnutrition, compared to MNA. The nutritional status of our subjects was also more satisfactory (71.9% well-nourished) than those reported by others [8]. All these findings together might explain why the cut-off point for GNRI in our study (compared to MNA) was higher compared to the original ranges that indicated only scores lower than 98 as malnutrition risk [34].

All the three indices in our study had a negative correlation with age. This was in concord with most previous studies [29, 30, 39, 40]; however, some studies reported no significant between-group differences for the nutritional indices, regarding age [41]. In agreement with our results, many studies have found significant differences for BMI, body weight, and albumin between the elderly at no risk of malnutrition and those at risk, or suffering from it [11, 29, 30, 34, 35, 40, 41]. GNRI had a stronger correlation with these parameters in our study; only a few studies have reported the correlation for all the three indices, and this prevents appropriate comparison of the findings from multiple studies. Our results were concordant with findings of Abd-El-Gawad et al. [29], Cereda et al. [30] and Dent et al. [11] studies, in this respect.

Aging is accompanied with decreased serum albumin [42, 43]. In addition, low-level inflammation which results in immune-related diseases can affect diet and nutritional status of the elderly and eventually lead to diminished albumin levels [44, 45]. Catabolic state of body due to the inflammatory mediators also adds on to depletion of albumin reserves, in one hand and muscle catabolism, on the other [16, 46]. All these together may justify the correlation between age, albumin levels as well as anthropometric measures, and GNRI.

Our study had some limitations; GNRI was only assessed in comparison with MNA indices and further nutritional assessment tools could not be applied due to limited funding sources. Moreover, we were unable to follow our participants to study their different nutritional outcomes. A major drawback of our study was that, despite the great importance of sarcopenia assessment while studying malnutrition in the elderly, we failed to perform the relevant measurement in our subjects, because of the funding limitations. However, the present research owns some strength as follows. First, most of the previous GNRI studies were on hospitalized elderly, whereas we studied on non-hospitalized elderly. Second, it had enough power due to higher sample size.

Conclusion

Although GNRI had lower sensitivity compared to MNAs and might not be an efficient tool in screening malnutrition in an Iranian society, it had moderate correlation with both MNAs and also anthropometric and biochemical parameters, highly related to nutritional status. In addition, GNRI might be a more applicable tool when the elderly are incapable of independent participation in MNA assessments or the aim is to direct the limited funding sources to genuinely malnourished elderly. Further studies are warranted to confirm these results.

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Author contributions MS-A: Formulating the research questions, designing the study, carrying it out, analyzing the data, revision and approval of the final manuscript. EV-M: Analyzing the data, drafting the manuscript, revision and approval of the final manuscript. NK: Sampling of the study, carrying it out, revision and approval of the final manuscript. LD-F: Sampling of the study, carrying it out, revision and

approval of the final manuscript. PK: Sampling of the study, carrying it out, revision and approval of the final manuscript. MA-J: Analyzing the data, revision and approval of the final manuscript.

Compliance with ethical standards

Conflict of interest We declare herein that we have no conflict of interests.

Ethical approval This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the ethics committee of Tabriz University of Medical Sciences (Ethics code:TBZMED.REC.1394.24).

Informed consent Written informed consent was obtained from all subjects.

References

1. World Health Organization (2015) 10 facts on aging and life course. http://www.whoint/topics/ageing/en/htm. Accessed 2 Dec 2016
2. Mirzaie M, Shams M (2007) Demographic of elderly in Iran based on 1956–2006 headcounts. Salmand 2:326–331 [Persian]
3. Gilhooly M, Hanlon P, Mowat H, Cullen B, Macdonald S, Whyte B (2007) Successful ageing in an area of deprivation: Part 1-A qualitative exploration of the role of life experiences in good health in old age. Public health 121:807–813
4. Wellman NS, Kamp B (2017) Nutrition in Aging. In: Mahan LK, Raymond JL (eds) Krause's food and the nutrition care process, 14th edn. Elsevier, St. Louis, p. 368
5. Oliveira M, Fogaca K, Leandro-Merhi VA (2009) Nutritional status and functional capacity of hospitalized elderly. Nutr J 8:54
6. Morley JE (2012) Undernutrition in older adults. Fam pract 29:i89-i93
7. Vellas B, Lauque S, Andrieu S, Nourhashemi F, Rolland Y, Baumgartner R, Garry P (2001) Nutrition assessment in the elderly. Curr Opin Clin Nutr Metab Care 4:5–8
8. Joghataei MT, Nejati V (2006) Assessment of health status of elderly people in the city of kashan. Salmand 1:3–10 [Persian]
9. Drescher T, Singler K, Ulrich A, Koller M, Keller U, Christ-Crain M, Kressig W R (2010) Comparison of two malnutrition risk screening methods (MNA and NRS 2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. Eur J Clin Nutr 64:887–893
10. Durán Alert P, Milà Villarroel R, Formiga F, Virgili Casas N, Vilarasau Farré C (2012) Assessing risk screening methods of malnutrition in geriatric patients: Mini Nutritional Assessment (MNA) versus Geriatric Nutritional Risk Index (GNRI). Nutr Hosp 27:590–598
11. Dent E, Visvanathan R, Piantadosi C, Chapman I (2012) Nutritional screening tools as predictors of mortality, functional decline, and move to higher level care in older people: a systematic review. J Nutr Gerontol Geriatr 31:97–145
12. Kamo T, Nishida Y (2013) Direct and indirect effects of nutritional status, physical function and cognitive function on activities of daily living in Japanese older adults requiring long-term care. Geriatr Gerontol Int 14:799–805
13. Kim G, Kim H, Kim Y, Kim HJ, Son JI, Kim SY, Chang N (2012) Relationship of cognitive function with plasma homocysteine, folate, vitamin B12 levels and nutrient intake in cognitively impaired elderly. FASEB J 26:627
14. Ogawa S (2014) Nutritional management of older adults with cognitive decline and dementia. Geriatr Gerontol Int 14:17–22
15. Fabian E, Bogner M, Kickinger A, Wagner KH, Elmadfa I (2011) Intake of medication and vitamin status in the elderly. Ann Nutr Metab 58:118–125
16. Guigoz Y, Lauque S, Vellas BJ (2002) Identifying the elderly at risk for malnutrition: the Mini Nutritional Assessment. Clin Geriatr Med 18:737–757
17. Aliabadi M, Kimiaghar M, Ghior Mobarhan M, Ielati Faizabadi AA (2007) Prevalence of malnutrition and some related factors in Khorasan Razavi Province. Iran J Nutr Food Sci 2:45–56 (**Persian**)
18. Kuzuya M, Kanda S, Koike T, Suzuki Y, Satake S, Iguchi A (2005) Evaluation of mini-nutritional assessment for Japanese frail elderly. Nutrition 21:498–503
19. Donini L, Savina C, Rosano A, Cannella C (2007) Systematic review of nutritional status evaluation and screening tools in the elderly. J Nutr Health Aging 11:421
20. Cereda E, Vanotti A (2007) The new Geriatric Nutritional Risk Index is a good predictor of muscle dysfunction in institutionalized older patients. Clin Nutr 26:78–83
21. Cereda E, Vanotti A (2008) Short dietary assessment improves muscle dysfunction identification by Geriatric Nutritional Risk Index in uncomplicated institutionalised patients over 70 years old. Clin Nutr 27:126–132
22. Cereda E, Pusani C, Limonta D, Vanotti A (2008) The association of Geriatric Nutritional Risk Index and total lymphocyte count with short-term nutrition-related complications in institutionalised elderly. J Am Coll Nutr 27:406–413
23. Chumlea WC, Roche AF, Steinbaugh ML (1985) Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc 33:116–120
24. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, Benazeth S, Cynober L, Aussel C (2005) Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr 82:777–783
25. Jyrkkä J, Enlund H, Lavikainen P, Sulkava R, Hartikainen S (2011) Association of polypharmacy with nutritional status, functional ability and cognitive capacity over a three-year period in an elderly population. Pharmacoepidemiol Drug Saf 20:514–522
26. Ghazi L, Fereshtehnejad SM, AbbasiFard S, Sadeghi M, Shahidi GA, Lökk J (2015) Mini Nutritional Assessment (MNA) is rather a reliable and valid instrument to assess nutritional status in Iranian healthy adults and elderly with a chronic disease. Ecol Food Nutr 54:342–357
27. van Bokhorst-de van der Schueren, Guaitoli MA, Jansma PR, de Vet EP HC (2014) Nutrition screening tools: does one size fit all? A systematic review of screening tools for the hospital setting. Clin Nutr 33:39–58
28. Landis JR, Koch GG (1997) The measurement of observer agreement for categorical data. Biometrics 33:159–174
29. Abd-El-Gawad WM, Abou-Hashem RM, El Maraghy MO, Amin GE (2014) The validity of Geriatric Nutrition Risk Index: simple tool for prediction of nutritional-related complication of hospitalized elderly patients. Comparison with Mini Nutritional Assessment. Clin Nurt 33:1108–1116
30. Cereda E, Pusani C, Limonta D, Vanotti A (2009) The ability of the Geriatric Nutritional Risk Index to assess the nutritional status and predict the outcome of home-care resident elderly: a comparison with the Mini Nutritional Assessment. Br J Nutr 102:563–570
31. Poulia KA, Yannakoulia M, Karageorgou D, Gamaletsou M, Panagiotakos DB, Sipsas NV, Zampelas A (2012) Evaluation of the efficacy of six nutritional screening tools to predict malnutrition in the elderly. Clin Nutr 31:378–385

32. Gómez-Candela C, Serrano Labajos R, García-Vazquez N, Valero Pérez M, Morato Martínez M, Santurino Fontecha C, González Madroño A, Palma-Milla S; Comisión de Nutrición del Hospital Universitario La Paz (2013) Complete process of implantation of a nutritional risk screening system in the University Hospital La Paz, Madrid. Nutr Hosp 28:2165–2174 (**In Spanish**)
33. Kang SH, Cho KH, Park JW, Woo Yoon K, Do JY (2013) Geriatric Nutritional Risk Index as a prognostic factor in peritoneal dialysis patients. Perit Dial Int 33:405–410
34. Baek MH, Heo YR (2015) Evaluation of the efficacy of nutritional screening tools to predict malnutrition in the elderly at a geriatric care hospital. Nutr Res Pract 9:637–643
35. Edalat-Nejad M, Zameni F, Qlich-Khani M, Salehi F (2015) Geriatric Nutritional Risk Index: a mortality predictor in hemodialysis patients. Saudi J Kidney Dis Transpl 26:302–308
36. Campos del Portillo R, Palma MiIla S, García Váquez N, Plaza López B, Bermejo López L, Riobó Serván P, García-Luna PP, Gómez-Candela C (2015) Assessment of nutritional status in the healthcare setting in Spain. Nutr Hosp 31:196–208
37. Ranhoff AH, Gjøen AU, Mowé M (2005) Screening for malnutrition in elderly acute medical patients: the usefulness of MNA-SF. J Nutr Health Aging 9:221–225
38. Neelemaat F, Meijers J, Kruizenga H, van Ballegooijen H, van Bokhorst-de van der Schueren M (2011) Comparison of five malnutrition screening tools in one hospital inpatient sample. J Clin Nurs 20:2144–2152
39. Honda Y, Nagai T, Iwakami N, Sugano Y, Honda S, Okada A, Asaumi Y, Aiba T, Noguchi T, Kusano K, Ogawa H, Yasuda S, Anzai T, NaDEF investigators (2016) Usefulness of Geriatric Nutritional Risk Index for assessing nutritional status and its prognostic impact in patients aged ≥ 65 years with acute heart failure. Am J Cardiol 118:550–555
40. Izawa KP, Watanabe S, Oka K, Osada N, Omiya K, Brubaker PH, Shimizu H (2014) Differences in daily in-hospital physical activity and geriatric nutritional risk index in older cardiac inpatients: preliminary results. Aging Clin Exp Res 26:599–605
41. Izawa KP, Watanabe S (2016) Relation of nutritional status to physiological outcomes after cardiac surgery in elderly patients with diabetes mellitus: a preliminary study. Aging Clin Exp Res 28:1267–1271
42. Kubota K, Kadomura T, Ohta K, Koyama K, Okuda H, Kobayashi M, Ishii C, Fujiwara Y, Nishiora T, Ohmae Y, Ohmae T, Kitajima M (2012) Analyses of laboratory data and establishment of reference values and intervals for healthy elderly people. J Nutr Health Aging 16:412–416
43. Sergi G, Coin A, Enzi G, Volpato S, Inelmen EM, Buttarello M, Peloso M, Mulone S, Marin S, Bonometto P (2006) Role of visceral proteins in detecting malnutrition in the elderly. Eur J Clin Nutr 60:203–209
44. Schrager MA, Metter EJ, Simonsick E, Ble A, Bandinelli S, Lauretani F, Ferrucci L (2007) Sarcopenic obesity and inflammationin the InCHIANTI study. J Appl Physiol 102:919–925
45. World Health Organization (2012) Nutrition for older persons. Geneva, Switzerland: World Health Organization. http://www.who.int/nutrition/topics/ageing/en/index1.html. Accessed 15 Nov 2012
46. Roubenoff R (2000) Sarcopenia and its implication for the elderly. Eur J Clin Nutr 54:S40–S47