Low serum leptin serves as a biomarker of malnutrition in elderly patients

Bahareh Amirkalali a, Farshad Sharifi a,b, Hossein Fakhrzadeh a,⁎, Mojde Mirarfein a, Maryam Ghaderpanahi a, Zohreh Badamchizadeh a, Bagher Larijani a

aEndocrinology and Metabolism Research Institute, Tehran University of Medical Sciences, Tehran, 14117-137 Iran
bKahrizak Charity Foundation, Tehran, 18745-1454 Iran

Received 13 December 2009; revised 24 April 2010; accepted 3 May 2010

Abstract

Anthropometric and classical biologic markers of malnutrition, such as serum albumin, are limited because they are influenced by nonnutritional factors. We propose that a biologic parameter that both predicts nutritional status and is unaffected by nonnutritional factors would facilitate the diagnosis of malnutrition in the elderly. This cross-sectional study included 179 randomized elderly patients. Nutritional status was assessed by the Mini-Nutritional Assessment (MNA) instrument; other end points included anthropometric measures and biologic parameters. Subjects were divided into 3 groups based on MNA-defined nutritional status, and end point means were compared using 2-way analyses of variance adjusted by sex. Correlations between the most accurate biologic marker in predicting malnutrition and other biologic and clinical variables were assessed using Pearson correlation test. Multiple linear regressions were then performed to relate the best biomarker of malnutrition to specific parameters. Finally, leptin levels that predict malnutrition were determined using receiver operating characteristic curve cutoff values. The well-nourished group had significantly higher leptin (P = .001), weight, body mass index, mid-arm circumference, and calf circumference (all, P < .001) compared with the malnourished group and the at risk of malnutrition group. Serum leptin was the optimal biomarker of MNA-defined malnutrition and had significant positive correlations with weight (P = .003) and with all anthropometric values (all P < .001), but no significant correlation with C-reactive protein. Sex, weight, and triglyceride were the best predictors of serum leptin (all P < .001). The optimal cutoff value of serum leptin to detect malnutrition was 4.3 ng/mL in men and 25.7 ng/mL in women. Serum leptin may be a good predictor of nutritional status in elderly patients.

© 2010 Elsevier Inc. All rights reserved.

Keywords: Leptin; Malnutrition; Aged; ROC curve; Nutritional assessment; Human

Abbreviations: BMI, body mass index; BUN, blood urea nitrogen; CC, calf circumference; CRP, C-reactive protein; IBW, ideal body weight; MAC, mid-arm circumference; LDL-C, low-density lipoprotein cholesterol; MNA, Mini-Nutritional Assessment; T-C, total cholesterol; TG, triglyceride; WBC, white blood cell.

1. Introduction

Malnutrition in the elderly is considered a major public health problem. There is no consensus on the best method for accurately assessing nutritional status in the elderly. Fluid imbalance influences anthropometric measurements, and many of the classical biologic parameters are affected by nonnutritional factors such as inflammation. As such, many parameters are inappropriate indicators of nutritional status in the elderly, who often suffer from heart failure–associated edema or chronic diseases with inflammatory and/or septic complications [1].

For the elderly older than 70 years, European Society of Enteral and Parenteral Nutrition guidelines [2] recommend the use of the Mini-Nutritional Assessment (MNA) tool (Fig. 1) to detect the risk of malnutrition in home-care programs, nursing homes, and hospital settings [3,4]. The primary components of
**Mini Nutritional Assessment (MNA)**

<table>
<thead>
<tr>
<th>Last name:</th>
<th>First name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex:</td>
<td>Age:</td>
</tr>
</tbody>
</table>

Complete the screen by filling in the boxes with the appropriate numbers. Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

### Screening

**A** Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
- 0 = severe decrease in food intake
- 1 = moderate decrease in food intake
- 2 = no decrease in food intake

**B** Weight loss during the last 3 months
- 0 = weight loss greater than 3kg (6.6 lbs)
- 1 = does not know
- 2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
- 3 = no weight loss

**C** Mobility
- 0 = bed or chair bound
- 1 = able to get out of bed / chair but does not go out
- 2 = goes out

**D** Has suffered psychological stress or acute disease in the past 3 months?
- 0 = yes
- 1 = no

**E** Neuropsychological problems
- 0 = severe dementia or depression
- 1 = mild dementia
- 2 = no psychological problems

**F** Body Mass Index (BMI) (weight in kg) / (height in m²)
- 0 = BMI less than 19
- 1 = BMI 19 to less than 21
- 2 = BMI 21 to less than 23
- 3 = BMI 23 or greater

### Screening score
(subtotal max: 14 points)

- 12 points or greater: Normal – not at risk – no need to complete assessment
- 11 points or below: Possible malnutrition – continue assessment

### Assessment

**G** Lives independently (not in nursing home or hospital)
- 1 = yes
- 0 = no

**H** Takes more than 3 prescription drugs per day
- 0 = yes
- 1 = no

**I** Pressure sores or skin ulcers
- 0 = yes
- 1 = no

### J
**How many full meals does the patient eat daily?**
- 0 = 1 meal
- 1 = 2 meals
- 2 = 3 meals

### K
**Selected consumption markers for protein intake**
- At least one serving of dairy products (milk, cheese, yoghurt) per day
- Two or more servings of legumes or eggs per week
- Meat, fish or poultry every day

- 0.0 = if 0 or 1 yes
- 0.5 = if 2 yes
- 1.0 = if 3 yes

### L
**Consumes two or more servings of fruit or vegetables per day?**
- 0 = no
- 1 = yes

### M
**How much fluid (water, juice, coffee, tea, milk..) is consumed per day?**
- 0.0 = less than 3 cups
- 0.5 = 3 to 5 cups
- 1.0 = more than 5 cups

### N
**Mode of feeding**
- 0 = unable to eat without assistance
- 1 = self-fed with some difficulty
- 2 = self-fed without any problem

### O
**Self view of nutritional status**
- 0 = views self as being malnourished
- 1 = is uncertain of nutritional state
- 2 = views self as having no nutritional problem

### P
**In comparison with other people of the same age, how does the patient consider his / her health status?**
- 0.0 = not as good
- 0.5 = does not know
- 1.0 = as good
- 2.0 = better

### Q
**Mid-arm circumference (MAC) in cm**
- 0.0 = MAC less than 21
- 0.5 = MAC 21 to 22
- 1.0 = MAC 22 or greater

### R
**Calf circumference (CC) in cm**
- 0 = CC less than 31
- 1 = CC 31 or greater

### Assessment (max. 16 points)

<table>
<thead>
<tr>
<th>Assessment score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

### Screening score

<table>
<thead>
<tr>
<th>Screening score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

### Total Assessment (max. 30 points)

<table>
<thead>
<tr>
<th>Total Assessment score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

### Malnutrition Indicator Score

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 to 23.5 points</td>
<td>at risk of malnutrition</td>
</tr>
<tr>
<td>Less than 17 points</td>
<td>malnourished</td>
</tr>
</tbody>
</table>


© Nestlé. 1994, Revision 2008. NESTLE® 1/99-10M

For more information: www.mna-elderly.com

---

Fig. 1. A sample of MNA form used to detect malnutrition.
leptin and other nutritional-biologic markers (white blood cell [WBC], insulin, creatinine, total protein, albumin, C-reactive protein [CRP], leptin, low-density lipoprotein cholesterol [LDL-C], total cholesterol [T-C], triglyceride [TG], and blood urea nitrogen [BUN]) and performed anthropometric measurements (mid-arm circumference [MAC], calf circumference [CC], weight, and height) in a group of elderly people from the Kahrizak Charity Institute ethics committee and conformed to the Declaration of Helsinki. All subjects gave written informed consent. Patients were excluded if they if they had diabetes, thyroid disorders, edema, renal dysfunction (creatinine clearance ≤146 mL/min for men, ≤134 mL/min for women), or end-stage diseases. Creatinine clearance was calculated using the modified Cockcroft and Gault equation [6,7].

\[
\text{Creatinine clearance} \ (\text{ml/min}) = \frac{[140 - \text{age (y)}] \times \text{IBW}}{[\text{Serum creatinine (mg/dl)}^{72}] \\
\times (0.85 \text{ for females})}
\]

IBW = Ideal body weight in (kg)

Males : IBW = 50 kg + 2.3 kg for each in. over 5 ft.
Females : IBW = 45.5 kg + 2.3 kg for each in. over 5 ft.

2.2. Anthropometric measurements

Each patient underwent a clinical examination including measurement of MAC, CC, weight (kg), and height (cm) by professionals trained in anthropometric measurements. Weight was recorded in subjects wearing light cloth and in bare feet. Values were recorded to the nearest 0.1 kg using a 3-lever scale, calibrated with 1- and 5-kg standard weights after each measurement. Height was recorded to the nearest 0.1 cm using a flexible inextensible tape with bare feet placed closely together, standing erect with back and heels against the wall, and looking straight ahead. MAC was measured at the midpoint between the tip of the acromion and the olecranon process and was marked while the subject held the forearm in horizontal position. The measurement was performed on each subject’s arm hanging freely along the trunk with a flexible inextensible tape. Calf circumference was measured at the maximal circumference between the ankle and the knee, with a flexible inextensible tape, manipulated to maintain close contact with the skin without compression of underlying tissues. Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared.

2.3. Nutritional status

Nutritional status was defined according to the subject’s MNA score. We divided our patients into 3 groups. If the score was greater than 23.5 points, the patient was in a normal state of nutrition. If the score was 17 to 23.5 points, the patient was at risk of malnutrition, and if the score was less than 17, the patient was malnourished. A sample MNA form is shown in Fig. 1.

2.4. Biologic markers

Blood samples were drawn early in the morning after at least 12 hours of fasting. Measured biologic parameters were WBC, insulin, creatinine, total protein, albumin, CRP, leptin, LDL-C, T-C, TG, and BUN.

2.5. Methods of analysis

Total cholesterol, LDL-C, and TG were measured by enzymatic colorimetric technique ( ParsAzmun Kits, Karaj, Iran). Creatinine was measured using Jaffe reaction method ( ParsAzmun Kits). C-reactive protein was measured by the Enzymatic-Immunoturbidometric technique ( ParsAzmun Kits). Albumin was measured using photometric method ( Pars Azmoon kits, Tehran, Iran). Serum insulin and leptin were determined using enzyme-linked immunosorbent assay method ( DRG kits; DRG Instruments, Marburg, Germany).

2.6. Statistical analyses

Power analysis for the sample size in the study measurements is 95.99%. Mean values of clinical and biologic characteristics in the 3 subject groups (malnourished, at risk of malnutrition, and well nourished) were
compared using 2-way analyses of variance (ANOVA) adjusted by sex. The \( \chi^2 \) test was used to analyze the sex distribution in the 3 nutritional groups. Correlations between serum leptin and clinical or biologic variables were assessed using Pearson correlation tests. Finally, multiple linear regressions relating serum leptin to a specific subset of parameters were also performed. Cutoff values were determined using receiver operating characteristic curves. \( P \) values lower than .05 were considered significant. All computations were performed using SPSS statistical software (version 15; SPSS, Chicago, Ill).

3. Results

This cross-sectional study included 179 patients, age 75.8 ± 9.8 years, 44% male and 56% female. According to their MNA score, 6 patients (3.4%) were malnourished, 74 patients (41.3%) were at risk of malnutrition, and 99 patients (55.3%) were well nourished. A \( \chi^2 \) test showed that sex distribution was not significantly different among the 3 nutritional groups. Table 1 presents the mean ± SD values of biologic and clinical characteristics according to nutritional status, using 2-way ANOVA adjusted by sex.

Among the 3 nutritional groups (malnourished, at risk of malnutrition, and well-nourished groups), significant differences were observed concerning weight (kg; 42.75 ± 6.9 versus 54.01 ± 13.12 versus 65.05 ± 13, \( P < .001 \)), BMI (kg/m²; 19.16 ± 1.3 versus 22.67 ± 5.55 versus 26.25 ± 4.5, \( P < .001 \)), MAC (cm; 20.5 ± 2.3 versus 24.8 ± 3.5 versus 27.1 ± 4.44, \( P < .001 \)), CC (cm; 27 ± 1.7 versus 31.26 ± 4.44 versus 34.19 ± 3.26, \( P < .001 \)), serum leptin (ng/mL; 8.82 ± 5.8 versus 25.8 ± 33.7 versus 34.2 ± 34.6, \( P = .001 \)), and cholesterol (mg/dL; 153 ± 41.7 versus 198 ± 52.6 versus 184 ± 44.5, \( P = .034 \)). The well-nourished group had significantly higher leptin, weight, BMI, MAC, and CC compared with the malnourished group and the at risk of malnutrition group. Likewise, these factors were significantly higher in the at-risk group compared with the malnourished group. Serum cholesterol was highest in the at-risk group and the lowest value in the malnourished group. There were no significant differences between serum albumin and serum total protein (protein status markers) in the 3 nutritional groups. White blood cell and CRP were not significantly different among the 3 groups, which suggest that there was no significant difference in inflammatory activity.

The only 2 biologic parameters that were significantly different among the 3 groups were serum leptin and T-C.

Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Malnourished (6)</th>
<th>At risk of malnutrition (74)</th>
<th>Well nourished (99)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>75 ± 8.9</td>
<td>78 ± 9.9</td>
<td>74.2 ± 9.5</td>
<td>.52</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>42.75 ± 6.9</td>
<td>54.01 ± 13.12</td>
<td>65.05 ± 13</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>19.16 ± 1.3</td>
<td>22.67 ± 5.55</td>
<td>26.25 ± 4.5</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>MAC (cm)</td>
<td>20.5 ± 2.3</td>
<td>24.8 ± 3.5</td>
<td>27.1 ± 4.44</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>CC (cm)</td>
<td>27 ± 1.7</td>
<td>31.26 ± 4.44</td>
<td>34.19 ± 3.26</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>WBC (( x10^3/\text{mm}^3 ))</td>
<td>7.5 ± 1.7</td>
<td>99.5 ± 769.6</td>
<td>7.1 ± 2.1</td>
<td>.5</td>
</tr>
<tr>
<td>Serum insulin (( \mu \text{U/mL} ))</td>
<td>4.6 ± 3.02</td>
<td>5.5 ± 5.7</td>
<td>6.5 ± 5.8</td>
<td>.416</td>
</tr>
<tr>
<td>Serum Creatinine (mg/dL)</td>
<td>1.03 ± 0.05</td>
<td>1.18 ± 0.35</td>
<td>1.18 ± 0.34</td>
<td>.669</td>
</tr>
<tr>
<td>Serum total protein (g/dL)</td>
<td>7.1 ± 1.07</td>
<td>7.5 ± 0.7</td>
<td>7.4 ± 0.69</td>
<td>.67</td>
</tr>
<tr>
<td>Serum albumin (g/dL)</td>
<td>4.3 ± 0.28</td>
<td>4.7 ± 0.45</td>
<td>4.8 ± 0.47</td>
<td>.064</td>
</tr>
<tr>
<td>Serum CRP (mg/l)</td>
<td>7.3 ± 6.4</td>
<td>3.9 ± 5</td>
<td>3.6 ± 3.9</td>
<td>.178</td>
</tr>
<tr>
<td>Serum Leptin (mg/mL)</td>
<td>8.82 ± 5.8</td>
<td>25.8 ± 33.7</td>
<td>34.2 ± 34.6</td>
<td>.001*</td>
</tr>
<tr>
<td>Serum LDL (mg/dL)</td>
<td>90.8 ± 34.9</td>
<td>119.4 ± 39.3</td>
<td>111.1 ± 26.89</td>
<td>.069</td>
</tr>
<tr>
<td>Serum T-C (mg/dL)</td>
<td>153 ± 41.7</td>
<td>198 ± 52.6</td>
<td>184 ± 44.5</td>
<td>.034*</td>
</tr>
<tr>
<td>Serum TG (mg/dL)</td>
<td>115.2 ± 31.9</td>
<td>132.59 ± 68.43</td>
<td>143.5 ± 75.07</td>
<td>.289</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>18.3 ± 4.7</td>
<td>19.3 ± 7.1</td>
<td>19.9 ± 10.36</td>
<td>.84</td>
</tr>
</tbody>
</table>

Two-way ANOVA was used to analyze the data and it is presented as means ± SD. * \( P < .05 \) shows statistically significant difference between groups.

### Table 2

<table>
<thead>
<tr>
<th>Values</th>
<th>( r )</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>0.049</td>
<td>.567</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.249</td>
<td>.003*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>0.474</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>MAC (cm)</td>
<td>0.344</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>CC (cm)</td>
<td>0.353</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>WBC (( x10^3/\text{mm}^3 ))</td>
<td>-0.017</td>
<td>.854</td>
</tr>
<tr>
<td>Serum insulin (( \mu \text{U/mL} ))</td>
<td>0.294</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Serum creatinine (mg/dL)</td>
<td>-0.007</td>
<td>.93</td>
</tr>
<tr>
<td>Serum total protein (g/dL)</td>
<td>-0.162</td>
<td>.058</td>
</tr>
<tr>
<td>Serum albumin (g/dL)</td>
<td>-0.146</td>
<td>.091</td>
</tr>
<tr>
<td>Serum CRP (mg/l)</td>
<td>0.143</td>
<td>.95</td>
</tr>
<tr>
<td>Serum LDL (mg/dL)</td>
<td>0.259</td>
<td>.002*</td>
</tr>
<tr>
<td>Serum T-C (mg/dL)</td>
<td>0.298</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Serum TG (mg/dL)</td>
<td>0.382</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>-0.004</td>
<td>.96</td>
</tr>
</tbody>
</table>

Pearson correlation was used to analyze the data, and it is presented as \( r \) and \( P \) values. * \( P < .05 \) shows statistically significant correlation between serum leptin and the anthropometric or biologic value.
Serum leptin had a steady downward trend as malnutrition got worse, so it was chosen as the dependent variable to predict malnutrition. A Pearson correlation analysis examined independent correlations between serum leptin and clinical-biologic factors (Table 2). Leptin had significant positive correlations with BMI ($r = 0.474$, $P < .001$), weight ($r = 0.249$, $P = .003$), MAC ($r = 0.344$, $P < .001$), CC ($r = 0.353$, $P < .001$), insulin ($r = 0.294$, $P < .001$), T-C ($r = 0.298$, $P < .001$), LDL ($r = 0.259$, $P = .002$), and TG ($r = 0.382$, $P < .001$) levels. There were no significant correlations between serum leptin and albumin, total protein, and CRP.

We then performed a step-wise multiple linear regression analysis including serum leptin as the dependent variable and BMI, weight, MAC, CC, serum markers (insulin, T-C, LDL, TG), sex, and age as independent variables. Age is known to independently influence serum leptin [8] and was therefore included in the model, although it was not significantly correlated to leptin in our study. Sex ($\beta = 43.45$; 95% confidence interval [CI], 34.7-51.8; $P < .001$), weight ($\beta = 0.9$; 95% CI, 0.59-1.21; $P < .001$), and TG ($\beta = 0.377$; 95% CI, 0.02-0.13; $P < .001$) had the strongest relationships with serum leptin, and this relationship is defined in the following formula. This equation explains 54% ($R^2$) of variances.

Serum leptin value (ng/mL)  
$$= -100.9 + (43.45 \text{ sex}*) + [0.9 \text{ weight (kg)}] + $$  
$$[0.077 \text{ triglyceride (mg/DL)}]$$

* = 1 if male, = 2 if female

Next, we determined cutoff values on the receiver operating characteristic curves and found that the optimal cutoff value to detect well-nourished subjects from at-risk or malnourished subjects was 4.3 (ng/mL) in men (sensitivity 66.7%, specificity 73.1%) and 25.7 (ng/mL) in women (sensitivity 78.9%, specificity 50%).

4. Discussion

The use of MNA scores as defined by the European Society of Enteral and Parenteral Nutrition guidelines to detect malnutrition in the elderly is problematic because of poor memory for weight history and inaccurate anthropometric measurements due to technical errors or to fluid imbalances. The objective of this study was to determine biologic parameters best related to anthropometric markers of malnutrition and MNA score, to identify which parameter can be used to diagnose malnutrition in the elderly. As shown by the results, the hypothesis of the study was accepted. The only biologic parameter that was significantly down-regulated in malnourished subjects was serum leptin. Leptin was also significantly correlated to all 4 anthropometric parameters (weight, BMI, MAC, and CC). In addition, the more nourished the subject (as determined by higher MNA score), the higher the serum leptin.

A recent study [9] hypothesized that inflammatory disorders might lead to overexpression of the $ob$ gene in tissues and to increased serum leptin. Hamsters treated with proinflammatory lipopolysaccharide, interleukin-1, and tumor necrosis factor showed increased leptin mRNA in adipose tissue as well as elevated serum leptin [9]. In parallel, the animals displayed decreased food intake and loss of body weight. Thus, leptin overproduction is speculated to be a mechanism for inflammation-associated catabolism. However, as our study showed no significant difference in inflammation-associated CRP among the 3 nutritional groups, the differences in serum leptin levels are likely indicative of nutritional status.

Furthermore, this difference in leptinemia among the 3 nutritional classes cannot be explained by renal insufficiency, because subjects with abnormal creatinine clearance were excluded from study.

Decreased insulin may play a direct and important role in decreasing leptin production by the adipocyte during starvation, as insulin stimulates leptin gene expression in vitro, and leptin levels increase in vivo during a prolonged euglycemic insulin clamp [10]. A number of reports in humans [10] and animals [11,12] support a BMI and fat mass–independent regulatory influence of insulin on serum leptin levels. Our finding of a significant correlation between serum insulin and leptin ($r = 0.3$, $P < .001$) supports this view.

There were no significant differences between serum albumin and total protein among the 3 groups. This indicates that subjects who are MNA-scored as malnourished or at risk of malnutrition are not conclusively protein malnourished.

In this study, serum leptin in the 3 nutritional groups are higher than those observed by Cederholm et al [13] in malnourished elderly patients and by Haluzik et al [14] in malnourished and nourished elderly patients; these differences may be due to the larger number of female subjects in our study.

The lower serum leptin in malnourished elderly observed here was close to the results obtained by Cederholm et al [13] and Bouillanne et al [15]. Lower serum leptin concentration has been reported as a marker of poor nutritional status in chronic renal failure and children [16-18].

Different factors affect serum cholesterol level such as heredity, physical activity, and stress, which have not been evaluated in this study. The difference of these factors between the 3 nutritional groups may have resulted in the higher cholesterol level in at risk of malnutrition group compared with well-nourished group.

In conclusion, in the absence of confounding factors (diabetes, thyroid disease, low creatinine clearance, or end-stage diseases), serum leptin can be a good predictor of energy malnutrition. Leptin concentration decreases as malnutrition becomes more pronounced. In addition, compared with the MNA tool, it may be an easier and more reliable way to determine energy malnutrition in elderly people, as it does not depend on memory and avoids the intraexaminer and interexaminer errors common in
anthropometric measurements. It may be particularly useful for patients who cannot be weighed due to reduced mobility or to postural instability.

This study also has a limitation. The study group consisted of the elderly from a charity foundation. Therefore, it is hard to consider this sample representative of the elderly population. Further studies are required to evaluate serum leptin as a marker of malnutrition in different elderly populations.

Acknowledgment

This study was supported by Tehran University of Medical Sciences and the Management Board of the Kahrizak Charity Foundation. There is no conflict of interest.

References