Original Article

Malnutrition and associated geriatric syndromes in older outpatients: A comprehensive analysis

Busra Akpinar MD[1], Mursel Karadavut MD[2], Cemil İnci MD[1], Ozlem Avci MD[1], Merve Erat Sasmaz MD[1], Mustafa Utlu MD[1], Omer Karasahin MD[3], Pinar Tosun Tasar MD[1]

[1]Department of Internal Medicine, Division of Geriatrics, Ataturk University Faculty of Medicine, Erzurum, Turkiye
[2]Department of Internal Medicine, Division of Geriatrics, Erzurum Training and Research Hospital, Erzurum, Turkiye
[3]Department of Infectious Diseases and Clinical Microbiology, Erzurum Training and Research Hospital, Erzurum, Turkiye

Background and Objectives: This study aimed to investigate risk factors of malnutrition and the relationship between malnutrition and other geriatric syndromes in patients presenting to a geriatric outpatient clinic in Turkey. **Methods and Study Design:** The data of patients aged ≥65 years seen in a university geriatric outpatient clinic between January 2024 and January 2025 were retrospectively analyzed. Demographic, clinical, and laboratory data and the results of a comprehensive geriatric assessment were noted. The presence of malnutrition in patients was defined according to the Mini Nutritional Assessment–Long Form. **Results:** A total of 723 patients (55.9% women) with a median age of 70 years (range, 65-90 years) were included. The prevalence of malnutrition was 14.5% (95% CI 12.1–17.3%) and that of malnutrition risk was 23.9% (95% CI 21.0–27.2%). Malnutrition was found to be associated with advanced age ($p = 0.002$), female gender ($p < 0.001$), chronic heart failure ($p = 0.001$), coronary artery disease ($p = 0.001$), chronic lung disease ($p = 0.035$), osteoporosis ($p = 0.001$), and depression ($p = 0.001$). In geriatric assessment, patients with malnutrition had significantly lower scores for independence in basic and instrumental activities of daily living and cognitive function but higher comorbidity burden, number of drugs used, and depression, sarcopenia, and frailty scores ($p < 0.001$ for all). **Conclusions:** This study showed that malnutrition is highly prevalent in older adults and is associated with chronic diseases and geriatric syndromes such as depression, cognitive impairment, functional dependence, sarcopenia, frailty, and polypharmacy. Therefore, it is essential to provide early nutritional intervention to older individuals who are malnourished or at risk of malnutrition.

Key Words: older adults, malnutrition, risk factors, geriatric syndromes, nutritional status

INTRODUCTION

Worldwide, population aging is significantly impacting health systems and social dynamics. In 2017, 19.4% of the global population consisted of individuals aged 65 and over, and this rate is expected to reach 29.1% by 2080. In particular, the proportion of individuals aged 80 and over is projected to increase from 5.5% in 2017 to 12.7% by 2050.[1]

Geriatric syndromes significantly impair functioning and quality of life. They are multifaceted by nature and associated with longer hospital stays, higher health care fees, and increased mortality. As the name suggests, the incidence of these conditions increases with age.[2,3]

A good diet is the foundation of healthy aging. Although there is no universal consensus on the definition of malnutrition, the European Society of Clinical Nutrition and Metabolism (ESPEN) defines it as deficient nutrient uptake or absorption leading to changes in body composition and cell mass (reduced lean mass), reduced function, and impaired clinical outcomes.[4] The presence of malnutrition causes morbidity and mortality,[5] increased health expenditures,[6-8] and prolonged hospital stays.[9,10] According World Health Organization (WHO) data, malnutrition affects 1 in 6 people.[11] In the geriatric population, the frequency of malnutrition is high due to decreased appetite, changes in olfaction, difficulty swallowing, concomitant chronic diseases, physiological changes such as decreased energy needs, and increasing psychiatric diseases such as depression.[12] Malnutrition in older adults leads to decreases in bone and muscle mass, reduced muscle function and functional capacity, anemia, cognitive decline,

Corresponding Author: Dr Pinar Tosun Tasar, Department of Internal Medicine, Division of Geriatrics, Ataturk University Faculty of Medicine, Research Hospital, No:8, University District, Yakutiye/Erzurum, Turkiye, 25240
Tel: 905053988985
Email: pinar.tosun@gmail.com
Manuscript received 26 July 2025. Initial review completed 25 August 2025. Revision accepted 25 December 2025.
doi: 10.6133/apjcn.202604_35(2).0014

immune suppression, susceptibility to infections, and impaired wound healing.[13]

The use of validated screening tools is recommended for malnutrition screening and risk determination. The Mini Nutritional Assessment (MNA), which is considered the most effective screening tool for evaluating malnutrition risk in older adults, covers four main components: anthropometric measurements, clinical status, dietary assessment, and self-perceptions of health and nutrition. Although the MNA has a high diagnostic rate for malnutrition, it has disadvantages such as low specificity and the fact that it cannot be used with individuals who have dementia or communication problems.[14]

A study conducted in Turkey by Saka et al. showed that malnutrition was more common in those with depression, fecal incontinence, and impaired cognitive function.[14] Another study by Gündüz et al. showed that age, education level, body mass index (BMI), comorbidities, and the presence of depression were associated with malnutrition.[14] To our knowledge, no study has demonstrated the relationship between malnutrition and other geriatric syndromes among older adults in our region. In this study, we aimed to investigate malnutrition risk factors and the relationship between malnutrition and other geriatric syndromes in older adults presenting to a geriatric outpatient clinic.

METHODS

A retrospective cross-sectional study was conducted with older patients who presented to the geriatric outpatient clinic of our university between January 2024 and January 2025 and underwent a comprehensive geriatric assessment. Demographic characteristics (age, sex) and data regarding the patients' chronic diseases and medications used were obtained from the hospital electronic records and patient charts.

Patients presenting to the outpatient clinic were assessed for malnutrition using the MNA, and the results were analyzed retrospectively. The MNA long form (MNA-LF) consists of 18 items in 4 sections:

-Anthropometric measurements: Includes BMI, mid-arm circumference, and calf circumference (3 items)

-Dietary habits: Includes items regarding food and fluid intake and need for assistance with eating (6 items)

-Global assessment: Includes questions about level of independence, drugs used, mobility, mental status, skin changes, and acute stress in the last three months (6 items)

-Subjective assessment: Questions what the respondent thinks about their nutritional state and health status (2 items)

Scores on the MNA-LF range between 0 and 30, with a score of 24 and above interpreted as normal nutritional status, scores of 17-23.5 as malnutrition risk, and a score less than 17 as malnutrition.[15] The validity and reliability of the MNA for Turkish patients was conducted by Sarıkaya et al. in 2015.[16]

Functional status and level of independence were assessed using the Barthel Index for Activities of Daily Living (ADL) and Lawton & Brody Instrumental Activities of Daily Living Scale (IADL). The Barthel Index includes questions in a total of 10 domains: grooming, bathing, dressing, eating, toileting, bowel and bladder control, climbing and descending stairs, mobility, and transfers.[17] The total score is out of 100. The validity and reliability study of the Barthel ADL Index in our country was conducted by Küçükdeveci et al. in 2000.[18] The IADL Scale was developed by Lawton and Brody in 1969[19] and the validity and reliability study in our country was conducted by Yardımcı et al. in 1995.[20] It is used to determine to evaluate phone use, shopping, food/drink preparation, house cleaning, laundry, travel, responsible medication use, and independence in financial affairs. Scoring is on a scale of 0 to 2-4 for each activity, and the total score range is 0–8.

The Mini-Mental State Examination (MMSE) was used for cognitive assessment. Developed by Folstein et al. in 1975,[21] it is the most widely used neuropsychological test worldwide. The Turkish validation studies for educated and uneducated individuals in our country were conducted by Güngen et al. in 2002[22] and Babacan Yıldız et al. in 2016,[23] respectively. The MMSE consists of two parts. In the first part, the patient is asked questions verbally and expected to answer appropriately. This section assesses orientation, memory, and attention, and the highest total score that can be obtained is 21. The second part includes naming, carrying out verbal and written commands, writing a spontaneous sentence, and copying two nested pentagonal shapes, and the highest total score that can be obtained is 9.

Depression screening was performed with the Geriatric Depression Scale (GDS). This assessment tool was developed by Yesavage et al. in 1983[24] and the Turkish validity and reliability study was conducted by Ertan et al. in 1997.[25] It consists of a total of 30 questions, Depending on age, education, and complaints, scores of 0-4 are considered normal, whereas scores of 5-8 indicate mild depression, 9-11 moderate depression, and 12-15 severe depression.

The FRAIL Scale was used to assess the patients for frailty. It was developed by the International Nutrition and Aging Association (IANA) to identify individuals at risk of frailty.[26] The validity and reliability study was performed by Hymabaccus et al.[27] It consists of five items: fatigue, resistance (climbing stairs unaided and without resting), ambulation, illness (number of chronic diseases), and weight loss. Each item is scored 0 or 1, and a score of 3 or higher is interpreted as frailty.

The SARC-F questionnaire was developed as a potential rapid screening test for sarcopenia.[28] The Turkish validity and reliability study of SARC-F was conducted by Bahat et al. in 2018.[29] SARC-F has five components: strength, walking with assistance, rising up from a chair, climbing stairs, and falls. Each component is scored from 0 to 2, for a total score ranges of 0 to 10. Scores of 4 and above indicate risk of sarcopenia.

In addition, the following laboratory data from the period when the patients were noted: white blood cell count, neutrophil count, lymphocyte count, hemoglobin (Hb), hematocrit (Hct), platelet count, mean platelet volume, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase, gamma glutamyl transferase, lactate dehydrogenase, total protein, albumin, bilirubin, blood urea nitrogen (BUN), creatinine, serum iron,

total iron binding capacity, sodium, glucose, potassium, calcium, phosphorus, magnesium, uric acid, ferritin, sedimentation, C-reactive protein, 25 hydroxy vitamin D, prealbumin, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, and hemoglobin A1c. The relationship between these variables and malnutrition was evaluated.

Osteoporosis assessment

Among patients who underwent DEXA (dual-energy X-ray absorptiometry) for bone mineral density measurement, those with a T-score of ≤ -2.5 were considered osteoporotic in accordance with the WHO criteria. Measurements were performed from the lumbar (L1-L4) and femoral region as per standard protocols.[30]

Statistical analysis

All study data were analyzed using a suitable statistical package program. Continuous variables were tested for normal distribution using the Kolmogorov-Smirnov test; those that did not fit the normal distribution were presented as median and interquartile range (IQR). Categorical variables were expressed as frequency and percentage. Comparisons of categorical variables based on malnutrition status were done using the chi-square test or with Fisher's exact test if the expected number of observations was <5. As continuous data were not normally distributed, comparisons were done using nonparametric tests: the Kruskal-Wallis test for three or more groups and the Mann-Whitney U test for two groups. Candidate variables for multivariable logistic regression were defined as those with p <0.05 in univariable analyses together with clinically important covariates (age and sex). The initial set included: age, sex, chronic heart failure (CHF), coronary artery disease (CAD), chronic obstructive pulmonary disease (COPD), osteoporosis, GDS (initially continuous; recoded a priori to a clinically meaningful binary variable with GDS >9 indicating depression, GDS ≤9 indicating no depression), IADL, ADL, MMSE, SARC-F, FRAIL, number of chronic diseases, number of medications, Charlson Comorbidity Index (CCI), Hb, Hct, AST, ALT, total cholesterol, HDL, triglycerides, calcium, phosphorus, ferritin, folate, free thyroxine (fT4), TSH, albumin, and total protein. Multicollinearity was assessed by pairwise correlations and variance inflation factors (VIF); VIF ≥10 was deemed indicative of high collinearity. Accordingly, only one of Hb-Hct (Hb selected for clinical interpretability) and only one of ADL-IADL (ADL retained as a measure of functional status) were entered; for the albumin-total protein pair, total protein was initially preferred. A backward (likelihood ratio) procedure was then applied (entry $p = 0.05$, removal $p = 0.10$). During backward elimination, age, sex, Hb, ADL, total protein, HDL, triglycerides, ALT, CCI, FRAIL, number of chronic diseases, and number of medications lost significance in the multivariable context and were removed. The final model included age, sex, severe cognitive impairment (MMSE ≤18), ADL, depression (GDS >9), osteoporosis, SARC-F, total cholesterol, calcium, phosphorus, fT4, TSH, ferritin, and folate. Model fit was verified with the Hosmer–Lemeshow test (non-significant p), discrimination was assessed by area under the curve (AUC) in receiver operating characteristic analysis, and explained variance was summarized by Nagelkerke R^2. All tests were two-sided with a significance threshold of $p < 0.05$.

Before the study, clearance was obtained from the Atatürk University Faculty of Medicine Clinical Research Ethics Committee (date: 28.02.2025, meeting no: B.30.2.ATA.0.01.00/184, decision no: 78).

RESULTS

The median age of the 723 patients included in this study was 70 (range, 65–90), and 55.9% (n = 404) of the patients were female. The prevalence of malnutrition was 14.5% (95% CI 12.1–17.3%; n = 105), and another 23.9% (95% CI 21.0–27.2%; n = 173) of the patients were evaluated as at risk for malnutrition. The remaining 61.5% (n = 445) of the patients were not malnourished.

The distribution of demographic characteristics according to the patients' malnutrition status is presented in Table 1. The proportion of female patients was significantly higher in the malnutrition group compared to the malnutrition risk and no malnutrition groups ($p < 0.001$). In addition, the mean age was significantly higher in the malnutrition group compared to the at-risk and no

Table 1. Distribution of demographic characteristics according to malnutrition status

	Malnutrition			*p*
	Yes (n=105)	Risk (n=173)	No (n=445)	
Age, median (IQR)	71 (68 – 77)	70 (67 – 74)	70 (67 – 74)	0.002
Sex, Female, n (%)	73 (69.5)	107 (61.8)	224 (50.3)	<0.001
Occupation, n (%)				0.085
Retired	29 (27.6)	66 (38.2)	220 (49.4)	
Homemaker	73 (69.5)	103 (59.5)	215 (48.3)	
Worker/civil servant	2 (1.9)	-	2 (0.4)	
Farmer	1 (1.0)	3 (1.7)	4 (0.4)	
Unemployed	-	1 (0.6)	4 (0.9)	
Education level, n (%)				0.435
Illiterate	37 (35.2)	70 (40.5)	158 (35.5)	
Literate	16 (15.2)	23 (13.3)	45 (10.1)	
Elementary school	34 (32.4)	52 (30.1)	164 (36.9)	
Middle school	5 (4.8)	11 (6.4)	26 (5.8)	
High school	12 (11.4)	11 (6.4)	34 (7.6)	
Higher education	1 (1.0)	6 (3.5)	18 (4.0)	

malnutrition groups ($p = 0.002$).

There were also statistically significant differences in the frequency of CHF, CAD, COPD, depression, and osteoporosis according to malnutrition status (Table 2). CHF, CAD, and depression were more common in individuals with malnutrition or malnutrition risk compared to those without malnutrition ($p < 0.05$) but did not differ significantly between the malnutrition and malnutrition risk groups. The frequency of COPD was also higher among individuals with malnutrition compared to those without malnutrition ($p < 0.05$), and the frequency of osteoporosis was higher among individuals with malnutrition compared to both individuals at risk of malnutrition and without malnutrition ($p < 0.05$). However, there was no statistical difference in the frequency of osteoporosis between the no malnutrition and malnutrition risk groups.

The distribution of laboratory findings according to malnutrition status is presented in Table 3. Significant relationships were observed between malnutrition status and Hb, Hct, serum iron, ALT, AST, triglycerides, total cholesterol, HDL cholesterol, phosphorus, total protein, fT4, TSH, ferritin, folate, and international normalized ratio (INR) values. Hb, Hct, HDL cholesterol, and total protein differed significantly between all of the groups, with the highest values in patients without malnutrition and the lowest in those with malnutrition ($p < 0.05$). Calcium, folate, triglycerides, total cholesterol, INR, TSH, AST, and ALT were significantly lower in individuals with malnutrition compared to those at risk of malnutrition and without malnutrition ($p < 0.05$) but did not differ significantly between the latter two groups. Similarly, fT4 and ferritin were significantly higher in individuals with malnutrition compared to both patients at risk of malnutrition and those without malnutrition ($p < 0.05$) while the differences between the latter two groups did not reach significance. Serum iron concentration was significantly higher in individuals without malnutrition compared to individuals with both malnutrition and malnutrition risk ($p < 0.001$). However, there was no significant difference between individuals with malnutrition and those at risk of malnutrition. A significant difference in phosphorus concentration was only seen between individuals with malnutrition compared to individuals without malnutrition ($p < 0.05$).

The distribution of various geriatric assessment results according to malnutrition status is examined in Table 4. IADL, ADL, and MMSE results were found to be significantly lower in individuals diagnosed with malnutrition compared to the groups at risk of malnutrition and without malnutrition, while CCI, Yesavage GDS, SARC-F, number of chronic diseases, and number of drugs used were significantly higher. Individuals at risk of malnutrition also had lower IADL and MMSE scores and higher CCI, Yesavage GDS, and SARC-F scores compared to those without malnutrition. Patients without malnutrition and those at risk showed no significant differences in ADL score, FRAIL Scale score, number of diseases, or number of drugs used. When depression was defined as a GDS score greater than 9 points, 42.9% of malnourished patients, 17.3% of those at risk of malnutrition, and 5.2% of well-nourished patients had depression ($p < 0.001$).

Table 5 summarizes the results of the expanded multivariable logistic regression (including all 723 patients). Depression (GDS >9) remained the strongest determinant of malnutrition, with 8.1-fold higher odds of malnutrition in depressed patients. Osteoporosis was also independently associated with malnutrition (2.1-fold higher odds). Male sex was linked to lower odds of malnutrition (55% lower than in females), age showed a positive but borderline association (4–5% higher odds per additional year; $p = 0.09$). In the prespecified core covariates, severe cognitive impairment (MMSE ≤18) and ADL were not independently associated after adjustment. Among continuous biomarkers, higher total cholesterol, calcium, TSH, and folate were protective, whereas higher phosphorus, fT4, and ferritin were associated with greater odds of malnutrition. Notably, SARC-F score lost statistical significance in the model. Overall performance of the model remained strong (Nagelkerke $R^2 \approx 0.39$; AUC ≈ 0.86; Hosmer–Lemeshow $p > 0.05$), indicating good discrimination and calibration.

DISCUSSION

Our study showed that malnutrition is common among older outpatients and clusters with several geriatric syndromes and chronic conditions. Among 723 patients (mean age 70 years, 55.9% female) presenting to the geriatric outpatient clinic of our university hospital, malnutrition was identified in 14.5% and malnutrition risk in 23.9% of the patients, both of which were associated with adverse clinical outcomes. In bivariate analyses, patients with malnutrition or risk of malnutrition had lower ADL, IADL, and MMSE scores and higher frailty, depression, and SARC F scores, higher comorbidity burden, and more medications than well-nourished patients. However, in the multivariable model, only depression, osteoporosis, female sex, and several biochemical markers (higher fT4, ferritin, and phosphorus; lower TSH, folate, calcium, and total cholesterol) remained independently associated with malnutrition.

Individuals who were malnourished or at risk of malnutrition were older, and the rate of malnutrition was higher among women. Malnutrition is a geriatric syndrome with significant negative consequences for older adults in our country, as elsewhere in the world.[31] The prevalence of malnutrition in older adults varies regionally according to countries' socioeconomic level. Rates are lower in high-income countries and markedly higher in low- and middle-income countries. For example, while the malnutrition rate in Europe is 2.1%, this rate is 4.8% in Asia. It was reported as 12.2% in Iran, 16.3% in India, 24.0% in Nepal, and 26.6% in Ethiopia.[32,33] Similarly, studies conducted in Turkey have shown that malnutrition rates vary between 6.6% and 19.0%, and the prevalence of malnutrition risk is 29.1%–31.6%.[34-36] Our estimates are therefore consistent with those reported for community dwelling and outpatient older adults in similar socioeconomic contexts and highlight that almost two in five patients seen in geriatric clinics are either malnourished or at risk of malnutrition. Similar rates were obtained in our study, supporting the role of geographical and socioeconomic factors in these regional differences. Malnutri-

tion risk is as important as malnutrition and has been associated with various adverse clinical outcomes.[37,38]

Our study showed that MNA scores decreased with increasing age. Our findings are consistent with the literature.[37,38] Factors such as impaired chewing and swallowing, loss of appetite, and more difficult food access are thought to contribute to malnutrition.[37,38]

The effect of depression on malnutrition has not been fully elucidated. However, neurotransmitter and hormonal changes in depression cause anorexia and reduced nutritional intake.[39,40] Numerous studies in the literature have demonstrated a positive correlation between depression and malnutrition.[41-45] In our study, depression was present in 42.9% of patients with malnutrition, 17.3% of patients at risk of malnutrition, and only 5.2% of well-nourished patients. In logistic regression analysis, depression was the strongest independent risk factor for malnutrition, associated with 8.1-fold higher odds. As depression is a treatable condition, our findings suggest that early diagnosis and treatment may play a critical role in preventing malnutrition.

Malnutrition can lead to sarcopenia because calorie and protein intake are insufficient to maintain muscle mass. The presence of sarcopenia may also lead to reduced mobility, thereby impairing meal preparation and shopping.[46] Therefore, the results of sarcopenia and malnutrition largely overlap.[47] Consistent with this, malnourished and at risk participants in our study had higher SARC F and FRAIL scores than well nourished individuals. However, SARC F did not remain an independent determinant in the multivariable model, suggesting that the relationship between malnutrition, sarcopenia, and frailty is partly mediated by depression, comorbidity burden, and functional decline.

In keeping with the close interplay between thyroid function and energy metabolism, we observed that higher fT4 and lower TSH concentrations were independently associated with malnutrition, with approximately 2.5-fold higher odds with each unit increase in fT4 and about a 30% reduction in odds per unit increase in TSH. Higher concentrations of ft4 and ft3 hormones in the body lead to a higher basal metabolic rate. This increases the demand for nutrients necessary for the maintenance of vital activities and basic physiological functions, resulting in malnutrition. Changes in TSH level also impact leptin levels and production, which can also cause malnutrition.[48,49]

In our study, the rate of malnutrition was higher among women. Although the relationship between gender and malnutrition has not been clearly explained, it has been reported that older women are more prone to malnutrition than men due to reasons such as longer lifespan, widowhood, and greater burden of chronic diseases.[50-52] Age-related losses in muscle mass and functional impairments also exacerbate this situation.[53] Additionally, some reports indicate that women receive lower pensions than men,[53] and studies in Europe have shown that lower income levels are linked to reduced food intake and increased risk of malnutrition.[53] However, it should be noted that cultural differences also exist in this regard.[53] A study conducted among older people living in Portugal and Turkey also showed that the rate of malnutrition is higher in women.[53]

Chronic heart failure, coronary artery disease, and chronic lung disease were more frequent among malnourished participants in our study, in line with previous work

Table 2. Distribution of chronic diseases according to malnutrition status

Chronic disease, n (%)	Malnutrition			*p*
	Yes (n=105)	Risk (n=173)	No (n=445)	
Hypertension	70 (66.7)	100 (57.8)	261 (58.7)	0.276
Diabetes mellitus	40 (38.1)	78 (45.1)	177 (39.8)	0.401
CHF	9 (8.6)	13 (7.5)	10 (2.2)	0.001
CAD	29 (27.6)	44 (25.4)	67 (15.1)	0.001
CVD	5 (4.8)	11 (6.4)	12 (2.7)	0.093
COPD	17 (16.2)	20 (11.6)	36 (8.1)	0.035
Asthma	5 (4.8)	12 (6.9)	16 (3.6)	0.204
PVD	3 (2.9)	2 (1.2)	8 (1.8)	0.585
Dementia	1 (1.0)	5 (2.9)	3 (0.7)	0.080
Depression	7 (6.79)	9 (5.2)	5 (1.1)	0.001
Hypothyroidism	15 (14.3)	19 (11.0)	48 (10.8)	0.588
Hyperthyroidism	6 (5.7)	2 (1.2)	16 (3.6)	0.105
Hypoparathyroidism	–	1 (0.6)	2 (0.4)	0.755
Hyperparathyroidism	1 (1.0)	1 (0.6)	1 (0.2)	0.539
CKD	4 (3.8)	9 (5.2)	14 (3.1)	0.480
Osteoporosis	28 (26.7)	24 (13.9)	52 (11.7)	0.001
BPH	11 (10.5)	30 (17.3)	75 (16.9)	0.241
Chronic liver disease	2 (1.9)	1 (0.6)	5 (1.1)	0.590
Parkinson's disease	2 (1.9)	1 (0.6)	8 (1.8)	0.506
Malignancy	5 (4.8)	5 (2.9)	15 (3.4)	0.700
Hearing impairment	5 (4.8)	13 (7.5)	25 (5.6)	0.574
Vision impairment	6 (5.7)	18 (10.4)	33 (7.4)	0.312
Functional limitation	3 (2.9)	2 (1.2)	2 (0.5)	0.074
History of delirium	1 (1.0)	1 (0.6)	4 (0.9)	0.915

CHF, Chronic heart failure; CAD, Coronary artery disease; CVD, Cerebrovascular disease; COPD, Chronic obstructive pulmonary disease; PVD, Peripheral vascular disease; CKD, Chronic kidney disease; BPH, Benign prostatic hypertrophy.

Table 3. Distribution of laboratory findings according to malnutrition status

Laboratory result, median (IQR)	Malnutrition			*p*
	Yes (n=105)	Risk (n=173)	No (n=445)	
WBC	7.02 (6.04 – 8.33)	7.42 (6.16 – 9.28)	7.37 (6.12 – 8.72)	0.328
Lymphocytes	2.01 (1.63 – 2.41)	2.14 (1.67 – 2.68)	2.21 (1.7 – 2.68)	0.238
Neutrophils	4.17 (3.50 – 5.31)	4.32 (3.43 – 5.83)	4.16 (3.31 – 5.44)	0.360
Monocytes	0.54 (0.465 – 0.675)	0.56 (0.43 – 0.695)	0.55 (0.45 – 0.68)	0.835
Hb (g/dL)	13.5 (12.45 – 14.6)	14.2 (13.2 – 15.0)	14.7 (13.7 – 15.6)	<0.001
Hct (%)	40.3 (37.5 – 44.0)	42.6 (39.8 – 45.1)	43.7 (41.3 – 46.5)	<0.001
MCV (fL)	86.5 (84.7 – 90.5)	87.3 (84.6 – 89.8)	87.9 (85.0 – 90.8)	0.056
PLT (mcL)	250 (210 – 305)	259 (216 – 304)	255 (211 – 297)	0.721
MPV (fL)	10.0 (9.5 – 10.5)	10.1 (9.55 – 10.6)	10.0 (9.5 – 10.7)	0.808
ESR (mm/h)	13.5 (11 – 18)	15 (7 – 24)	11.4 (6 – 20.95)	0.051
Glucose (mg/dL)	101.6 (87.3 – 127.1)	98.9 (85.65 – 118.3)	96.5 (84.9 – 122.7)	0.557
BUN (mg/dL)	17.1 (14.4 – 22.4)	16.7 (13.9 – 20.3)	16.0 (13.3 – 19.1)	0.056
Creatinine (mg/dL)	0.75 (0.66 – 0.88)	0.78 (0.66 – 0.95)	0.80 (0.69 – 0.98)	0.089
Na (mEq/L)	141 (139 – 142)	140 (138 – 142)	140 (138 – 142)	0.069
K (mEq/L)	4.31 (4.10 – 4.54)	4.39 (4.09 – 4.69)	4.40 (4.17 – 4.64)	0.083
Uric acid (mg/dL)	4.8 (4.4 – 5.6)	5.0 (4.3 – 6.1)	5.3 (4.5 – 6.1)	0.055
Iron (ng/mL)	68.1 (58.1 – 73.4)	66.6 (52.4 – 81.0)	73.2 (58.5 – 93.4)	<0.001
AST (U/L)	15 (13 – 18)	18 (15 – 22)	18 (15 – 22)	<0.001
ALT (U/L)	13 (9 – 17)	16 (12 – 19)	15 (12 – 20)	<0.001
LDH (U/L)	209 (188 – 232)	211 (189 – 242)	206 (184 – 231)	0.102
Triglycerides (mg/dL)	107 (88 – 158)	121 (88 – 158)	128 (98 – 171)	0.003
Total cholesterol (mg/dL)	176 (169 – 183)	193 (166 – 218)	195 (169 – 225)	0.001
HDL cholesterol (mg/dL)	46 (45 – 50)	48 (42 – 55)	52 (44 – 58)	<0.001
LDL cholesterol (mg/dL)	109 (91 – 201)	118 (93 – 155)	118 (95 – 146)	0.876
Ca (mg/dL)	9.28 (8.98 – 9.57)	9.41 (9.14 – 9.81)	9.45 (9.11 – 9.77)	0.002
P (mg/dL)	3.39 (3.08 – 3.69)	3.35 (3.00 – 3.67)	3.25 (2.89 – 3.62)	0.041
Mg (mEq/L)	1.91 (1.73 – 2.00)	1.92 (1.77 – 2.045)	1.91 (1.77 – 2.03)	0.244
Albumin (g/dL)	4.15 (3.94 – 4.36)	4.1 (3.94 – 4.29)	4.20 (4.00 – 4.40)	0.004
Total bilirubin (mg/dL)	0.53 (0.43 – 0.76)	0.59 (0.43 – 0.84)	0.60 (0.46 – 0.79)	0.282
Direct bilirubin (mg/dL)	0.17 (0.13 – 0.21)	0.12 (0.09 – 0.19)	0.13 (0.10 – 0.18)	0.128
ALP (IU/L)	71 (66 – 86)	73 (64 – 89)	74 (62 – 89)	0.526
Total protein (g/dL)	6.8 (6.6 – 7.0)	6.9 (6.7 – 7.3)	7.1 (6.8 – 7.4)	<0.001
CRP (mg/dL)	4 (1.95 – 7.305)	4.12 (2.54 – 7.99)	4 (2.16 – 7.095)	0.394
GGT (IU/L)	21.5 (14 – 25.7)	21 (15.4 – 31.5)	20.3 (16.15 – 27.2)	0.821
fT4 (ng/dL)	1.07 (0.99 – 1.25)	0.97 (0.83 – 1.07)	0.90 (0.80 – 1.08)	<0.001
TSH (mIU/L)	1.22 (0.86 – 1.56)	1.37 (0.94 – 2.30)	1.61 (1.04 – 2.46)	0.002
Ferritin (ng/mL)	92.4 (40.1 – 124.5)	58.0 (31.0 – 104.5)	49.7 (27.9 – 100.3)	<0.001
Folate (ng/mL)	7.35 (7.26 – 7.45)	8.90 (7.14 – 10.66)	8.60 (7.00 – 10.78)	<0.001
Vitamin B12 (pg/mL)	284 (238 – 343)	263 (211 – 334)	258 (199 – 329)	0.053
Vitamin D25OH (ng/mL)	12 (5 – 17)	12 (7 – 19)	12 (8 – 20)	0.265
HbA1C (%)	6.8 (6.0 – 8.4)	7.2 (5.8 – 12.7)	6.4 (5.7 – 10.6)	0.055
INR	1.13 (1.13 – 1.13)	1.07 (1.02 – 1.11)	1.07 (1.02 – 1.12)	<0.001

WBC, White blood cells; Hb, Hemoglobin; Hct, Hematocrit; MCV, Mean red cell volume; PLT, Platelets; MPV: Mean platelet volume; ESR: Erythrocyte sedimentation rate; BUN, Blood urea nitrogen; Na, Sodium; K, Potassium; Fe, Iron; AST, Aspartate transferase; ALT, Alanine Aminotransferase; LDH, Lactate dehydrogenase; TG, Triglycerides; HDL, High-density lipoprotein; LDL, Low-density lipoprotein; Ca, Calcium; P, Phosphorus; Mg, Magnesium; ALP, Alkaline phosphatase; CRP, C-reactive protein; GGT, Gamma glutamyl transferase; fT4, Free thyroxine; TSH, Thyroid stimulating hormone; INR, International normalized ratio.

Table 4. Distribution of geriatric assessment scores according to malnutrition status

Score, mean ± SD	Malnutrition			*p*
	Yes (n=105)	Risk (n=173)	No (n=445)	
CCI	4.09±1.46	3.69±1.35	3.37±1.10	<0.001
ADL	85.76±22.64	91.36±15.31	97.30±6.92	<0.001
IADL	6.03±2.61	6.68±2.20	7.56±1.57	<0.001
MMSE	22.75±5.29	24.63±4.88	26.22±4.31	<0.001
GDS	10.15±7.87	5.58±3.77	2.96±3.29	<0.001
SARC-F	3.50±2.73	2.67±2.61	1.44±1.75	<0.001
FRAIL	2.07±1.45	1.92±1.16	1.20±1.15	<0.001
Number of chronic diseases	3.0±2.0	2.8±1.8	2.3±1.5	<0.001
Number of medications used	4.8±3.5	4.4±3.2	3.1±2.6	<0.001
GDS > 9 points, n (%)	45 (42.9)	30 (17.3)	23 (5.2)	<0.001

CCI, Charlson Comorbidity Index; ADL, Barthel Index for Activities of Daily Living; IADL, Lawton & Brody's Instrumental Activities of Daily Living Scale; MMSE, Mini Mental State Examination; GDS, Yesavage Geriatric Depression Scale; SARC-F, Simple Sarcopenia Questionnaire.

Table 5. Results of the logistic regression model of variables that may be associated with malnutrition

Variable	B	S.E.	Exp(B) (OR)	95% CI for Exp(B)	*p*
Age (per year)	0.045	0.027	1.046	0.993 – 1.103	0.090
Male sex (ref: female)	-0.799	0.330	0.450	0.236 – 0.858	0.015
Severe cognitive impairment (MMSE ≤ 18)	0.012	0.446	1.012	0.422 – 2.423	0.979
ADL (Barthel) score (per 1 point)	-0.002	0.011	0.998	0.976 – 1.019	0.824
Depression (GDS > 9)	2.086	0.309	8.056	4.393 – 14.775	<0.001
Osteoporosis	0.733	0.338	2.081	1.073 – 4.034	0.030
SARC-F score (per 1 point)	0.088	0.073	1.092	0.946 – 1.260	0.228
Total cholesterol (mg/dL, per 1)	-0.011	0.004	0.989	0.982 – 0.996	0.003
Calcium (mg/dL, per 1)	-0.490	0.195	0.613	0.418 – 0.898	0.012
Phosphorus (mg/dL, per 1)	0.106	0.048	1.112	1.012 – 1.222	0.027
TSH (mIU/L, per 1)	-0.352	0.122	0.703	0.553 – 0.894	0.004
fT4 (ng/dL, per 1)	0.931	0.232	2.537	1.610 – 3.996	<0.001
Ferritin (ng/mL, per 1)	0.004	0.001	1.004	1.002 – 1.006	0.001
Folate (ng/mL, per 1)	-0.098	0.039	0.907	0.840 – 0.978	0.012

MMSE, Mini-Mental State Examination; ADL: Activities of Daily Living; SARC-F, Simple Sarcopenia Questionnaire; fT4, Free thyroxine; TSH, Thyroid-stimulating hormone

suggesting that chronic inflammatory conditions are accompanied by loss of appetite, increased catabolism, and poorer nutritional status.[54,55] However, after adjustment for other covariates, only osteoporosis remained independently associated with malnutrition. Malnutrition is an important cause of secondary osteoporosis. Insufficient protein intake may adversely affect bone health. Studies show that high-quality protein intake reduces inflammation and the risk of fractures.[52,56-59] Factors such as calcium and vitamin D deficiency, high sodium and phosphorus, and alcohol consumption are also known as risk factors for osteoporosis.[60,61] The association between osteoporosis and malnutrition in our cohort (twofold higher odds) suggests that systematic nutritional assessment should accompany osteoporosis screening and management in geriatric practice.

Low serum lipid levels have also been associated with chronic diseases and poor nutritional status in older adults.[53,54] In our study, higher total cholesterol concentrations were independently protective against malnutrition, whereas lower triglyceride and HDL levels were observed in malnourished patients. One plausible explanation is that systemic inflammation and catabolic states suppress hepatic lipoprotein synthesis, reduce fat-soluble vitamin absorption, and decrease energy reserves, thereby linking low lipid levels to muscle wasting and functional decline.[62-66] Low serum lipid levels have also been associated with chronic diseases and poor nutritional status in older adults.

Protein–energy malnutrition is closely linked to the development of anemia through impaired intake and absorption of iron and other hematopoietic nutrients.[67,68] Consistent with previous Turkish studies reporting higher anemia rates among malnourished older adults,[69] we found that serum iron concentrations were significantly higher in well nourished participants than in those with malnutrition or at risk of malnutrition. These data underline the importance of systematically investigating and treating anemia in older adults with malnutrition, as correction of iron and other micronutrient deficiencies may contribute to functional recovery.

Taken together, these findings suggest that routine nutritional screening in geriatric outpatient clinics should be integrated with systematic assessment of depressive symptoms, osteoporosis, thyroid function, lipid profile, and anemia to identify high risk patients and intervene early.

Strengths and limitations

Strengths of our study are that all patients underwent a comprehensive geriatric assessment, the MNA-LF was used, the sample size was sufficient, and few other studies on this topic have been conducted in our region. Limitations are that the study was retrospective and conducted in a single center. Our study was also conducted only among patients who presented to the outpatient clinic, so it does not represent the entire population in our region. Furthermore, biomarkers important in indicating malnutrition (such as prealbumin) were not evaluated, and although we analyzed the number of medications used by the patients, the drugs themselves were not examined. Another limitation is that we included both clinical and laboratory variables in the same multivariable model, which can complicate interpretation of the results. However, this integrative approach allowed us to assess a broad range of potential risk factors concurrently and to determine their independent associations with malnutrition by adjusting for confounding between clinical conditions and biomarker levels.

Conclusion

The rate of malnutrition in our patients was found to be similar to that in previous studies. Malnutrition risk was significantly associated with geriatric syndromes such as depression, cognitive impairment, and sarcopenia. Therefore, it is of great importance to provide early nutritional intervention to older adults with malnutrition or at risk of malnutrition. Nutritional assessment in older adults should be carried out in conjunction with evaluation of depression, cognitive status, sarcopenia, and functional independence, and interventions should utilize a multidisciplinary approach.

DISCLOSURE ON THE USE OF AI AND AI-ASSISTED TECHNOLOGIES

No artificial intelligence (AI) tools were used in the writing, analysis, or preparation of this manuscript.

CONFLICT OF INTEREST AND FUNDING DISCLOSURES

The authors declare that they have no commercial or financial relationship that could create a conflict of interest in regards to the study.

REFERENCES

1. The Department of Economic and Social Affairs. World Population Ageing. 2017; https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Report.pdf.
2. Soysal P, Heybeli C, Koc Okudur S, Caliskan Bozyel E, Smith L, Kazancioglu R. Prevalence and co-incidence of geriatric syndromes according to glomerular filtration rate in older patients. Int Urol Nephrol. 2023;55:469-76.
3. Soysal P, Smith L. The prevalence and co-existence of geriatric syndromes in older patients with dementia compared to those without dementia. Aging Clin Exp Res. 2024;36:66.
4. Bakulin IG, Novozhenov VG. [On the issue of the diagnosis and correction of disease-related malnutrition]. Voen Med Zh. 2003;324:44-7. (in Turkish)
5. Sullivan DH, Morley JE, Johnson LE, et al. The GAIN (Geriatric Anorexia Nutrition) registry: the impact of appetite and weight on mortality in a long-term care population. J Nutr Health Aging. 2002;6:275-81.
6. Pirlich M, Schutz T, Norman K, et al. The German hospital malnutrition study. Clin Nutr. 2006;25:563-72.
7. Ockenga J, Freudenreich M, Zakonsky R, Norman K, Pirlich M, Lochs H. Nutritional assessment and management in hospitalised patients: implication for DRG-based reimbursement and health care quality. Clin Nutr. 2005;24:913-9.
8. Correia MI, Campos AC, Study EC. Prevalence of hospital malnutrition in Latin America: the multicenter ELAN study. Nutrition. 2003;19:823-5.
9. Pichard C, Kyle UG, Morabia A, Perrier A, Vermeulen B, Unger P. Nutritional assessment: lean body mass depletion at hospital admission is associated with an increased length of stay. Am J Clin Nutr. 2004;79:613-8.
10. Chima CS, Barco K, Dewitt ML, Maeda M, Teran JC, Mullen KD. Relationship of nutritional status to length of stay, hospital costs, and discharge status of patients hospitalized in the medicine service. J Am Diet Assoc. 1997;97:975-8; quiz 979-980.
11. de Onis M, Blossner M, Borghi E, Frongillo EA, Morris R. Estimates of global prevalence of childhood underweight in 1990 and 2015. JAMA. 2004;291:2600-6.
12. Tomasiewicz A, Polański J, Tański W. Advancing the Understanding of Malnutrition in the Elderly Population: Current Insights and Future Directions. Nutrients. 2024;16:2502.
13. Chapman IM. Nutritional disorders in the elderly. Med Clin North Am. 2006;90:887-907.
14. Donini LM, Poggiogalle E, Molfino A, et al. Mini-Nutritional Assessment, Malnutrition Universal Screening Tool, and Nutrition Risk Screening Tool for the Nutritional Evaluation of Older Nursing Home Residents. J Am Med Dir Assoc. 2016;17:959 e911-58.
15. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev. 1996;54:S59-65.
16. Sarikaya D, Halil M, Kuyumcu ME, et al. Mini nutritional assessment test long and short form are valid screening tools in Turkish older adults. Arch Gerontol Geriatr. 2015;61:56-60.
17. Mahoney FI, Barthel DW. Functional Evaluation: The Barthel Index. Md State Med J. 1965;14:61-5.
18. Kucukdeveci AA, Yavuzer G, Tennant A, Suldur N, Sonel B, Arasil T. Adaptation of the modified Barthel Index for use in physical medicine and rehabilitation in Turkey. Scand J Rehabil Med. 2000;32:87-92.
19. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9:179-86.
20. Yardımcı E. İstanbul'da Yaşayan Yaşlı Öğretmenlerin Sağlık Sorunlarının Günlük Yaşam Aktiviteleri İle İlişkisi, İstanbul Üniversitesi; 1995. (in Turkish)
21. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12:189-98.
22. Gungen C, Ertan T, Eker E, Yasar R, Engin F. [Reliability and validity of the standardized Mini Mental State Examination in the diagnosis of mild dementia in Turkish population]. Turk Psikiyatri Derg. 2002;13:273-81. (in Turkish)
23. Babacan-Yildiz G, Ur-Ozcelik E, Kolukisa M, Isik AT, Gursoy E, Kocaman G, Celebi A. [Validity and Reliability Studies of Modified Mini Mental State Examination (MMSE-E) For Turkish Illiterate Patients With Diagnosis of Alzheimer Disease]. Turk Psikiyatri Derg. 2016;27:41-6. (in Turkish)
24. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, Leirer VO. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982;17:37-49.
25. Ertan T, Eker E, Şar V. [Validity and reliability of the Geriatric Depression Scale in the Turkish elderly population]. Archives of N europsychiatry. 1997;34:62-71. (in Turkish)
26. Woo J, Yu R, Wong M, Yeung F, Wong M, Lum C. Frailty Screening in the Community Using the FRAIL Scale. J Am Med Dir Assoc. 2015;16:412-9.
27. Hymabaccus BAB, Dogrul RT, Balcı C, et al.. An effective and practical tool to assess physical frailty in older adults: Turkish validation of the FRAIL Scale. Marmara Medical Journal. 2023;36:149-56.
28. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc. 2013;14:531-2.
29. Bahat G, Yilmaz O, Kilic C, Oren MM, Karan MA. Performance of SARC-F in Regard to Sarcopenia Definitions, Muscle Mass and Functional Measures. J Nutr Health Aging. 2018;22:898-903.
30. Blake GM, Fogelman I. Peripheral or central densitometry: does it matter which technique we use? J Clin Densitom. 2001;4:83-96.
31. Granic A, Mendonça N, Hill TR, Jagger C, Stevenson EJ, Mathers JC, Sayer AA. Nutrition in the Very Old. Nutrients. 2018;10:374.
32. Dent E, Wright ORL, Woo J, Hoogendijk EO. Malnutrition in older adults. Lancet. 2023;401:951-66.
33. Abate T, Mengistu B, Atnafu A, Derso T. Malnutrition and its determinants among older adults people in Addis Ababa, Ethiopia. BMC Geriatr. 2020;20:498.
34. Saka B, Kaya O, Ozturk GB, Erten N, Karan MA. Malnutrition in the elderly and its relationship with other geriatric syndromes. Clin Nutr. 2010;29:745-8.

35. Gunduz E, Eskin F, Gunduz M, et al. Malnutrition in Community-Dwelling Elderly in Turkey: A Multicenter, Cross-Sectional Study. Med Sci Monit. 2015;21:2750-6.
36. Kalan U, Arik F, Isik AT, Soysal P. Nutritional profiles of older adults according the Mini-Nutritional Assessment. Aging Clin Exp Res. 2020;32:673-80.
37. Kocyigit SE, Soysal P, Ates Bulut E, Isik AT. Malnutrition and Malnutrition Risk Can Be Associated with Systolic Orthostatic Hypotension in Older Adults. J Nutr Health Aging. 2018;22:928-33.
38. Slee A, Birch D, Stokoe D. The relationship between malnutrition risk and clinical outcomes in a cohort of frail older hospital patients. Clin Nutr ESPEN. 2016;15:57-62.
39. Al-Rasheed R, Alrasheedi R, Al Johani R, et al. Malnutrition in elderly and its relation to depression. International Journal Of Community Medicine And Public Health. 2018;5:2156.
40. Huffman GB. Evaluating and treating unintentional weight loss in the elderly. Am Fam Physician. 2002;65:640-50.
41. Velazquez-Alva MC, Irigoyen-Camacho ME, Cabrer-Rosales MF, et al. Prevalence of Malnutrition and Depression in Older Adults Living in Nursing Homes in Mexico City. Nutrients. 2020;12:2309.
42. Smoliner C, Norman K, Wagner KH, Hartig W, Lochs H, Pirlich M. Malnutrition and depression in the institutionalised elderly. Br J Nutr. 2009;102:1663-7.
43. German L, Feldblum I, Bilenko N, Castel H, Harman-Boehm I, Shahar DR. Depressive symptoms and risk for malnutrition among hospitalized elderly people. J Nutr Health Aging. 2008;12:313-8.
44. Madeira T, Peixoto-Placido C, Sousa-Santos N, et al. Malnutrition among older adults living in Portuguese nursing homes: the PEN-3S study. Public Health Nutr. 2019;22:486-97.
45. Cabrera MA, Mesas AE, Garcia AR, de Andrade SM. Malnutrition and depression among community-dwelling elderly people. J Am Med Dir Assoc. 2007;8:582-4.
46. Beckwee D, Delaere A, Aelbrecht S, et al. Exercise Interventions for the Prevention and Treatment of Sarcopenia. A Systematic Umbrella Review. J Nutr Health Aging. 2019;23:494-502.
47. Robinson SM, Reginster JY, Rizzoli R, et al. Does nutrition play a role in the prevention and management of sarcopenia? Clin Nutr. 2018;37:1121-32.
48. Long AM, Kwon JM, Lee G, et al. The extracellular matrix differentially directs myoblast motility and differentiation in distinct forms of muscular dystrophy: Dystrophic matrices alter myoblast motility. Matrix Biol. 2024;129:44-58.
49. Fragu P, Lemarchand-Venencie F, Benhamou S, et al. Long-term effects in skin and thyroid after radiotherapy for skin angiomas: a French retrospective cohort study. Eur J Cancer. 1991;27:1215-22.
50. Locher JL, Ritchie CS, Roth DL, Baker PS, Bodner EV, Allman RM. Social isolation, support, and capital and nutritional risk in an older sample: ethnic and gender differences. Soc Sci Med. 2005;60:747-61.
51. Castel H, Shahar D, Harman-Boehm I. Gender differences in factors associated with nutritional status of older medical patients. J Am Coll Nutr. 2006;25:128-34.
52. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, Benazeth S, Cynober L, Aussel C. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr. 2005;82:777-83.
53. Payette H. Nutrition as a determinant of functional autonomy and quality of life in aging: a research program. Can J Physiol Pharmacol. 2005;83:1061-70.
54. Castaneda C, Charnley JM, Evans WJ, Crim MC. Elderly women accommodate to a low-protein diet with losses of body cell mass, muscle function, and immune response. Am J Clin Nutr. 1995;62:30-9.
55. Teh R, Wham C, Kerse N, Robinson E, Doughty RN. How is the risk of undernutrition associated with cardiovascular disease among individuals of advanced age? J Nutr Health Aging. 2010;14:737-43.
56. Fung TT, McCullough ML, Newby PK, et al. Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. Am J Clin Nutr. 2005;82:163-73.
57. Cavicchia PP, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, Hebert JR. A new dietary inflammatory index predicts interval changes in serum high-sensitivity C-reactive protein. J Nutr. 2009;139:2365-72.
58. Tabung FK, Steck SE, Zhang J, et al. Construct validation of the dietary inflammatory index among postmenopausal women. Ann Epidemiol. 2015;25:398-405.
59. Zeng FF, Xue WQ, Cao WT, et al. Diet-quality scores and risk of hip fractures in elderly urban Chinese in Guangdong, China: a case-control study. Osteoporos Int. 2014;25:2131-41.
60. Gasmi A, Bjorklund G, Peana M, et al. Phosphocalcic metabolism and the role of vitamin D, vitamin K2, and nattokinase supplementation. Crit Rev Food Sci Nutr. 2022;62:7062-71.
61. Zhang YW, Cao MM, Li YJ, et al. Dietary Protein Intake in Relation to the Risk of Osteoporosis in Middle-Aged and Older Individuals: A Cross-Sectional Study. J Nutr Health Aging. 2022;26:252-8.
62. Ettinger WH, Miller LD, Albers JJ, Smith TK, Parks JS. Lipopolysaccharide and tumor necrosis factor cause a fall in plasma concentration of lecithin: cholesterol acyltransferase in cynomolgus monkeys. J Lipid Res. 1990;31:1099-107.
63. Beutler B. A proinflammatory mediator with potential relevance in aging. J Am Geriatr Soc. 1990;38:1027-36.
64. Levine B, Kalman J, Mayer L, Fillit HM, Packer M. Elevated circulating levels of tumor necrosis factor in severe chronic heart failure. N Engl J Med. 1990;323:236-41.
65. Zarny L, Bernstein L. Serum Cholesterol:: An Indicator of Malnutrition. Journal of the American Dietetic Association. 1995;95:A25.
66. Shirahata T, Sato H, Yogi S, et al. Possible association of high-density lipoprotein cholesterol levels with trunk muscle deficits and decrease in energy expenditure in patients with or at risk for COPD: A pilot study. Respir Investig. 2022;60:720-4.
67. Yip R. Prevention and control of iron deficiency in developing countries. Curr Issues Public Health. 1996;2:253-63.
68. Cavalcanti DM, Lotufo CM, Borelli P, Ferreira ZS, Markus RP, Farsky SH. Endogenous glucocorticoids control neutrophil mobilization from bone marrow to blood and tissues in non-inflammatory conditions. Br J Pharmacol. 2007;152:1291-300.
69. Sahin S, Tasar PT, Simsek H, et al. Prevalence of anemia and malnutrition and their association in elderly nursing home residents. Aging Clin Exp Res. 2016;28:857-62.