Pavlović J, Račić M, Ivković N. Serum biomarkers associated with malnutrition and nutritional risk in elderly primary care patients: a cross-sectional study from Bosnia and Herzegovina. Zdr Varst. 2021;60(1):30-37. doi: 10.2478/sjph-2021-0006.

SERUM BIOMARKERS ASSOCIATED WITH MALNUTRITION AND NUTRITIONAL RISK IN ELDERLY PRIMARY CARE PATIENTS: A CROSS-SECTIONAL STUDY FROM BOSNIA AND HERZEGOVINA

SERUMSKI BIOLOŠKI OZNAČEVALCI, POVEZANI S PODHRANJENOSTJO IN PREHRANSKIM TVEGANJEM PRI STAREJŠIH BOLNIKIH NA PRIMARNI RAVNI: ŠTUDIJA IZ BOSNE IN HERCEGOVINE

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Received: Nov 11, 2019
Accepted: Nov 19, 2020

Original scientific article

ABSTRACT

Background: The aim of the study was to determine the ability of ferritin, haemoglobin, albumin and total cholesterol to identify nutritional risk and malnutrition among elderly primary care patients.

Methods: The cross-sectional study included 446 elderly adults over 65 years of age from four areas of Bosnia and Herzegovina. In addition to anthropometric, functional, cognitive and biochemical indicators, nutritional status was evaluated using 24-hour recall of meals, the Mini Nutritional Assessment (MNA), and Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II (SCREEN II).

Results: Malnourished/at-risk study respondents had lower mean levels of haemoglobin (P=0.001) and total cholesterol (P<0.001), compared to those with normal nutritional status. Albumin levels significantly differed regarding nutritional status (P=0.004), but not nutritional risk level (P=0.521). Significant differences in serum ferritin levels were not found between malnourished and normally nourished study respondents (P=0.779) Determinants of albumin level were eating more than three meals a day (P<0.001), fewer than two portions of fruit and vegetables a day (P=0.024), drinking one glass of wine (P<0.001) and reporting functional independence (P=0.011). The AUC curves for serum ferritin, albumin and total cholesterol levels in men and women, as well as for haemoglobin levels in women, were poor to fair (AUC<0.800).

Conclusion: Although ferritin, haemoglobin, albumin and total cholesterol may be useful biomarkers of nutritional status, their accuracy in diagnosing malnutrition and nutritional risk among elderly primary health care patients is limited.

Keywords:
elderly patients, biomarkers, malnutrition, nutritional status

IZVLEČEK

Uvod: *Cilj študije je bil določiti uporabnost merjenja ravni feritina, hemoglobina, albumina in skupnega holesterola za ugotavljanje prehranskega tveganja in podhranjenosti pri starejših bolnikih na primarni ravni.*

Metode: *V presečno študijo smo vključili 446 starejših odraslih, starih nad 65 let, s štirih območij Bosne in Hercegovine. Poleg upoštevanja antropometričnih, funkcijskih, kognitivnih in biokemijskih kazalnikov smo stanje prehranjenosti ocenili z navajanjem zaužitih obrokov v 24 urah, mini prehransko anamnezo (MNA) in vprašalnikom Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II (SCREEN II). [Ocenjevanje prehranskega tveganja, različica II (PRESEJANJE II).]*

Rezultati: *Podhranjeni anketiranci/anketiranci, ki so bili izpostavljeni tveganju, so imeli nižje povprečne ravni hemoglobina (p = 0,001) in skupnega holesterola (p < 0,001) kot normalno prehranjeni anketiranci. Ravni albumina so se pomembno razlikovale od ravni stanja prehranjenosti (p = 0,004), ne pa tudi stopnje prehranskega tveganja (p = 0,521). Med podhranjenimi in normalno prehranjenimi anketiranci nismo ugotovili pomembnih razlik v serumskem feritinu (p = 0,779). Determinante za vrednosti albumina so bile: uživanje več kot treh obrokov na dan (p < 0,001), manj kot dve porciji sadja in zelenjave na dan (p = 0,024), uživanje enega kozarca vina na dan (p < 0,001) ter poročanje o funkcionalni neodvisnosti (p = 0,011). Površine pod krivuljo (AUC) za ravni serumskega feritina, albumina in skupnega holesterola pri moških in ženskah ter ravni hemoglobina pri ženskah so bile majhne do zadovoljive (AUC < 0,800).*

Zaključek: *Čeprav so feritin, hemoglobin, albumin in skupni holesterol lahko uporabni biološki označevalci stanja prehranjenosti, je njihova natančnost pri diagnosticiranju podhranjenosti in prehranskega tveganja pri starejših bolnikih na primarni ravni omejena.*

Ključne besede:
starejši bolniki, biološki označevalci, podhranjenost, stanje prehranjenosti

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1 INTRODUCTION

Malnutrition is a prevalent health problem among the elderly population and one that is associated with increased morbidity, frailty, a weak immune system and functional dependency (1). Although health workers frequently use the term malnutrition as a synonym for undernutrition, every imbalance between the body's needs and food intake might be included in the definition of this health problem (2).

To determine nutritional risk and its contributing factors, the assessment of nutritional status and screening for malnutrition are recommended for people over 65 years of age at all levels of healthcare. Previous studies have shown that the intervals of the screening need to be adjusted to the living environment. Annual screenings are recommended for the population with a low prevalence of malnutrition (independent, community-dwellers), while frail elderly individuals (inpatients, institutionalised) should undergo an assessment at intervals of between one and three months (3–5).

The Global Leadership Initiative on Malnutrition (GLIM) recently endorsed criteria for the diagnosis of malnutrition in clinical practice, requiring the presence of at least one phenotypic criterion (weight loss, low body mass index and reduced muscle mass) and at least one etiological criterion (reduced food intake, disease-related inflammation) (6). However, these criteria have not yet been disseminated worldwide, and multiple approaches are still used to diagnose nutritional risk, including analysis of the complete metabolic panel (7).

In many countries, family physicians provide primary health care to older adults due of a lack of geriatricians. The high number of patients with multimorbidity and the burdens placed on the primary healthcare system by rising epidemic of non-communicable disease leave very little time for physicians to look for problems that elderly patients usually do not report if not specifically asked about (8), and that require the use of a time-/cost-effective approach to nutritional assessment (9).

As the results of previous studies analysing the usefulness of laboratory markers in assessing nutritional status are contradictory, we still do not know whether routine biochemical analysis could increase nutritional risk detection accuracy in a primary care setting (10–13).

The study's primary aim was to determine the ability of albumin, ferritin, total cholesterol and haemoglobin to identify nutritional risk and malnutrition among elderly primary care patients. The secondary aim was to identify the factors associated with the serum levels of these biomarkers.

2 METHODS

2.1 Sample and participants

The cross-sectional study included elderly adults over 65 years of age in four urban and rural areas of Bosnia and Herzegovina (Sarajevo, Foca, Pale, Rogatica).

The sample size was calculated using an EPI Info Statistical Package based on previous research, which showed that the prevalence of malnutrition among the geriatric population was 30% (4). A confidence interval of 95% and α of 5% were used. A list of random numbers was generated and applied to the primary health care database of older people. Elderly individuals were recruited between April and September 2018 from family medicine clinics and three nursing homes until the sample size of 446 respondents was achieved. The principal investigator informed prospective participants of the study's purpose and allowed them to ask questions before signing their informed consent to participate in the study. The exclusion criteria were: having a malignant disease, a severe mental condition, severe cognitive impairment, acute illness, stage 4 or 5 of chronic renal failure and stroke, or other conditions that could make collaboration with the respondent difficult. The principal investigator carried out all physical examinations, anthropometric measurements and functional tests, and trained research assistants distributed questionnaires.

2.2 Instruments

The socio-demographic questionnaire included data on age, gender, education, marital status, residence, mobility and social interactions. Nutritional status was evaluated by means of the 24-hour recall of meals, the Mini Nutritional Assessment (MNA) and Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II (SCREEN II). MNA measured the probability of malnutrition and consisted of two steps: screening and assessment.

Screening encompassed food intake decline, weight loss, mobility, neuropsychological problems and body mass index, while assessment scales included independence level, protein intake and medical assessment. The scores were summarised and grouped into three categories: malnourished (<17), at risk of being malnourished (17–23.5) and well-nourished (≥24) (14).

SCREEN II explored nutritional risks with 14 questions related to weight change, appetite, eating habits and behaviour. The scores are categorised as follows: <50 high nutrition risk, 50–53 moderate nutrition risk and ≥54 low nutrition risk (15). The internal consistency of the MNA in the Bosnian language was considered good (α=0.726) and SCREEN II fair (α=0.610).

The mean energy, macronutrient and micronutrient intakes of the study participants were calculated using the Nutrium program and compared with the Dietary Reference Intake (DRI) (16–18).

The Katz Index was used to evaluate the basic activities of daily living (ADL) (19). The cut-off point of 2 as scored per single item indicated severe impairments; participants scoring 5 or 6 were considered independent and fully functioning. The Lawton Scale, with scoring ranging from 0 (dependence) to 8 (independence), evaluated the instrumental activities of daily living (IADL) (20). The Functional Reach Test and Timed Up-and-Go Test were carried out to analyse physical function, mobility, balance and functional motion. For the Functional Reach Test, participants were instructed to stand with their dominant hand next to the measuring tape and reach as far as possible without taking a step. The average of three measurements was calculated, and a distance of <15 Cm indicated impaired balance (21). For the Timed Up and Go Test, the participants rose from the chair, walked three metres, turned around, returned to the chair and sat down again. The shortest time of three consecutive tests represented the test score. The threshold for impaired mobility was >20 seconds (22).

All anthropometric measurements were taken three times, with average values being calculated in centimetres (cm). Weight and height were recorded using a stadiometer and weighbridge. Calf, waist and mid-arm circumference were measured using a non-elastic tape measure. Skinfold thickness was assessed using a GIMA code 27320 calliper on triceps, biceps, subscapular and suprailiac fold (23).

A Six-Item Cognitive Impairment Test (6-CIT) was used to assess cognitive functions. The investigator analysed a number of mistakes made by the examinee, scoring the answers inversely. Scores were categorised as normal cognitive functioning (<10), mild cognitive impairment (10–19) and significant cognitive impairment (≥20) (24).

2.3 Key variables

Blood analyses were carried out in accordance with the protocols of Biochemical Medical Laboratory (Luzani, Sarajevo). Blood samples (fasting) were drawn from each subject using vacutainers and eprouvettes with separation gels (5 ml) and EDTA (3 ml).

On the same day, the samples for an analysis of total cholesterol, albumin and ferritin were separated by standard centrifugation at 2,000 rpm/min for seven minutes. After centrifugation, the samples were stored in the refrigerator at a temperature of 4–8°C for three days. Haemoglobin was measured on the Sysmex XP 300 (EDTA full blood sample). Serum concentrations for total cholesterol (using the GOD PAP method) and albumin (photometric test using Bromocresol) were determined in the Roche Modular autoanalyser (Roche, Stockholm). The analysis of ferritin levels was carried out on the Modular E170 analyser (CLIA analytics).

Based on previous research, the cut-off values for malnutrition were as follows: haemoglobin <120 g/L for men and <110 g/L for women (reference range 140–175g/l men, 123–153 g/l women), albumin <35 g/L (normal range 35–52 g/L), ferritin 30–400 ng/ml men, 13–150 ng/ml women, total cholesterol <3.88 mmol/l (11, 25).

2.4 Statistical analyses

All statistical analyses were performed using Statistical Package for Social Sciences for Windows (SPSS, version 25.0). The normality of distribution of variables was tested using the Kolmogorov-Smirnov test. Analysis of variance (ANOVA) and Student's t-test were applied to compare numerical variables. Owing to the small number of participants, individuals with malnutrition and those at risk of malnutrition as assessed by MNA were grouped, as were individuals with low and moderate nutritional risk per SCREEN II.

Associations between serum biomarkers and other malnutrition indicators were explored using univariate linear regression analysis, and independent variables with $P<0.05$ were included in multivariate regression models. To derive the sensitivity and specificity of the previously proposed cut-off values of serum biomarkers for differentiating between malnourished and well-nourished individuals, the receiver operating characteristic (ROC) curve and area under the curve (AUC) were used. An MNA score of <23.5 was used as a criterion. Criteria for the accuracy of serum biomarkers in diagnosing nutritional risk were as follows: excellent (AUC 0.90–1), good (AUC 0.80–0.90), fair (AUC 0.70–0.80), poor (AUC 0.60–0.70) and fail (AUC 0.50–0.60). A p-value of less than 0.05 was considered to be significant.

3 RESULTS

The study incorporated a total of 446 respondents. Of those, 300 were living in the community and 146 were residents of nursing homes. The majority of the respondents were retired women (251, 56.3%), widowers/single/unmarried (53%), with an average age of 76±7 years, and holding a secondary-school diploma or lower (85%).

Fifty-eight per cent of the participants (women 59%, men 57%) were at risk of malnutrition or had malnutrition per MNA, and 88% (90% of men, 87% of women) had a high nutritional risk per SCREEN II. The clinical characteristics of respondents by MNA and SCREEN II scores are listed in Table 1.

The mean values of all anthropometric parameters, functional indicators, cognitive assessment scoring, haemoglobin and total cholesterol were lower in a group of malnourished/at-risk respondents as assessed per MNA scoring (P<0.001). Albumin levels significantly differed in nutritional status (P=0.004), but not nutritional risks (P=0.521).

The mean values of albumin, total cholesterol, ferritin and haemoglobin of study participants were stratified by gender and age. In men and women, the levels of total cholesterol (P=0.004; P=0.031) and haemoglobin (P<0.001) were the lowest among octogenarians. A statistically significant change with age in mean ferritin levels was found in women (P<0.001), but not in men (P=0.080). The mean values of albumin decreased with age only in men (P=0.005) (Table 2).

The mean levels of fat intake by study participants met the target amounts in the DRI recommendations, while carbohydrate intake exceeded the guidance and protein intake was slightly lower than recommended. The intake of vitamins C, D, E and folate, as well as the intake of magnesium, calcium, zinc, and potassium, were substantially lower in comparison with the DRI recommendations (Table 3).

Table 1. Differences in anthropometric measurements, biomedical analyses and functional parameters in regard to categories of nutritional status per MNA[(a)] and SCREEN II[(b)].

Variable	MNA[(a)]			SCREEN II[(b)]		
	Malnutrition/ at-risk (N=259)	Normal nutrition (N=187)	P-value*	High risk (N=394)	Moderate/low risk (N=52)	P-value*
Albumin, *g/l*	44.5 (4.1)	45.8 (5.9)	0.004	45.2 (5.6)	45.2 (2.6)	0.521
Ferritin, *ng/ml*	157.1 (127.1)	153.6 (138.5)	0.779	156.3 (135.8)	144.8 (118.7)	0.507
Total cholesterol, *mmol/l*	5.0 (1.2)	5.4 (1.7)	<0.001	5.2 (1.2)	5.6 (1)	0.035
Haemoglobin, *g/l*	130 (18.9)	136.7 (14.5)	0.001	132.8 (17.5)	140.3 (11.0)	0.002
Waist circumference (cm)	91.9 (13.1)	99.0 (12.4)	<0.001	96.0 (13.7)	95.3 (8.5)	0.718
Mid-upper arm circumference (cm)	25.9 (3.7)	27.6 (3.3)	<0.001	26.8 (3.7)	26.9 (2.8)	0.953
Skinfold measurement (mm)	14.4 (3.5)	17.8 (7.3)	<0.001	15.9 (6.2)	19.6 (6.07)	0.001
Calf circumference (cm)	29.9 (4.3)	34.4 (3.5)	<0.001	32.2 (4.6)	33.8 (2.9)	0.017
BMI, kg/m^2	25.3 (5.2)	28.6 (4.5)	<0.001	27.0 (5.2)	27.8 (2.9)	0.269
6-CIT[(c)]	15.7 (5.9)	7.2 (5.8)	<0.001	11.8 (7.2)	5.3 (2.9)	<0.001
Timed Go and Up Test (secs)	23.8 (9.9)	13.4 (8.9)	<0.001	19.1 (10.9)	9.7 (4.8)	<0.001
Functional Reach Test (cm)	18.5 (8.5)	31.5 (11.1)	<0.001	24.2 (11.2)	38.2 (10.4)	<0.001
Katz Index	4.5 (1.9)	5.8 (0.8)	<0.001	5.2 (1.6)	6.0 (0)	<0.001
Lawton Scale	5.4 (3.1)	7.6 (1.3)	<0.001	6.5 (2.7)	8.0 (0)	<0.001

Data is presented as mean and SD

[(a)] MNA-SF – Mini Nutritional Assessment-Short Form, (b) SCREEN II – Seniors in the Community: Risk Evaluation for Eating and Nutrition, version II among octogenarians, (c) 6-CIT-Six Item Cognitive Impairment Test, *Students' t-test for independent samples

Table 2. Mean ferritin, haemoglobin albumin and total cholesterol concentrations in the Bosnian elderly population by age and gender.

Variable	Age/years	N (%)	Ferritin, ng/ml		Haemoglobin, g/l		Albumin, g/l		Total cholesterol, mmol/l	
			Mean (SD)	P*	Mean (SD)	P*	Mean (SD)	P*	Mean (SD)	P*
Men	65–74	96 (49)	227.7 (170.6)	0.080	146.3 (15.1)	<0.001	46.2 (3.2)	0.005	5.3 (1.1)	0.004
(n=195)	75–84	66 (33)	170.8 (131.3)		138.5 (17.9)		44.6 (3.1)		5.0 (1.1)	
	>85	33 (16)	194.3 (176.2)		135.4 (15.7)		44.6 (3.7)		4.6(1)	
Women	65–74	111 (44)	101.6 (6.3)	<0.001	133.6 (11.9)	<0.001	46.2 (8.4)	0.062	5.5 (1)	0.031
(n=251)	75–84	110 (43)	119.6 (9.4)		124.2 (13.9)		44.3 (3.8)		5.4 (1.3)	
	>85	30 (12)	168.9 (22.7)		117.4 (15.6)		44.4 (4.6)		4.9 (1.2)	

*ANOVA

Table 3. Average daily dietary intakes of study participants in comparison with DRI recommendations.

Variable*	Study participants' intake (n=446)	DRI Recommendation	% DRI
Energy (Cal)	1330 (329)	1900-2300	56-70%
Carbohydrate, g	224 (79)	130	>100%
Fat, g	32 (13)	20-35	>91%
Protein, g	42 (14)	46-56	75-91%
Vitamin B6, mg	0.84 (0.1)	1.5-1.7	49-56%
Vitamin B12, µg	1 (0.6)	2.4	74%
Vitamin C, mg	33 (15)	75-90	36-44 %
Vitamin E, mg	2 (2)	15	33%
Vitamin D, µg	2 (0.2)	15-20	12-16
Magnesium, mg	127 (45)	320-420	30-40%
Zinc, mg	4 (1)	9-11	37-46%
Calcium, mg	486 (116)	1,200	40%
Iron, mg	13 (4)	8-18	>50%
Potassium, g	1 (0.6)	4.7	28%
Sodium, g	0.60 (455)	1.2	50%
Folate, µg	115 (32)	400	29%

DRI – Recommended Dietary Allowance
*Data presented as mean and SD

Multivariate linear regression analyses showed that respondents that ate more than three meals a day (P<0.001) and fewer than two portions of fruit and vegetables (P=0.024), drank one glass of wine a day (P<0.001) and performed complex activities without assistance (P=0.011) had higher mean albumin values. Being female (P<0.001), having edentulism (P=0.011) and suffering from multimorbidity (P=0.005) had a negative association, while eating fruit/vegetables (P=0.028) and BMI (P=0.015) had a positive association with ferritin concentration. Women (P<0.001), older than 85 years of age (P=0.011) who used more than three medications (P=0.004) and had poor mobility (P=0.003) had lower haemoglobin values. Determinants of total cholesterol levels were being female (P<0.001), age (P=0.016), drinking sweetened drinks (P=0.024), balance (P<0.001) and whole milk consumption (P=0.001) (Table 4).

Table 4. Variables associated with biochemical biomarkers (multivariate linear regression analyses).

Variable	B	ß	95% CI for B		P-value[a]
			min	max	
Albumin[b]					
Meals, 3/day	1.55	0.19	0.73	2.22	<0.001
Fruit/vegetable servings	-0.59	-0.10	-1.02	0.13	0.024
Wine, one glass a day	4.21	0.23	2.35	5.87	<0.001
IADL	0.27	0.13	0.07	0.46	0.011
Ferritin[c]					
Female	-0.48	-0.21	-0.72	0.23	<0.001
Living in nursing home	-0.61	-0.25	-0.84	-0.34	<0.001
Edentulism	-0.03	-0.08	-0.70	0.00	0.011
Chronic diseases, more than 3	-0.01	-0.01	-0.28	0.02	0.005
Fruit/vegetable servings	0.01	-0.01	-0.02	0.06	0.028
BMI	0.01	0.07	0.00	0.02	0.015
Haemoglobin[d]					
Female	-12.95	-0.37	-15.45-	-9.85	<0.001
Age	-3.91	-0.10	-7.14	-0.68	0.011
Number of medications, more than 3	-0.83	-0.01	-1.39	-0.26	0.004
Wine, one glass a day	6.53	0.01	1.62	11.44	0.037
Mobility	-0.31	-0.20	-0.54	-0.11	0.003

Variable	B	ß	95% CI for B		P-value[a]
			min	max	
BMI	0.17	0.15	0.07	0.26	0.003
Fruit/vegetable servings	1.56	0.01	0.50	1.93	0.031
Total cholesterol[e]					
Female	0.40	0.17	0.19	0.60	<0.001
Age	-0.16	-0.06	-0.41	0.08	0.016
Drinking sweetened drinks, >2	0.07	0.08	0.00	0.14	0.024
Whole milk consumption	0.28	0.16	0.12	0.44	<0.001
Balance	0.03	0.32	0.20	0.40	<0.001

IADL – Instrumental Activities of Daily Living, BMI – body mass index

[a] Only statistically significant results are presented.

[b] Variables included in the model were age, number of meals, daily intake of fruit/vegetables, daily intake of wine, physical activity, IAD as assessed using the Lawton Scale.

[c] Variables included in the model were gender, living environment, edentulism, health perception, number of chronic diseases, daily intake of fruit/vegetables, daily intake of soft drinks, BMI.

[d] Variables included in the model were age, gender, having a hobby, number of visits to a family physician per year, number of medications, daily intake of wine, daily intake of dairy products, daily intake of fruit/vegetables, weekly intake of fish, 6-CIT score, BMI, mobility as assessed with the Timed Get-up-and-Go Test.

[e] Variables included in the model were age, gender, number of meals, number of meals eating outside of home per week, daily intake of soft drinks, daily intake of dairy products, daily intake of wine, balance as assessed by the Functional Reach Test, skinfold thickness and calf circumference.

The AUC curves for serum ferritin concentrations (AUC=0.447, 95 CI% of 0.191–0.703, P=0.717 in men; AUC=0.608, 95 CI% of 0.462–0.755, P=0.173 in women), haemoglobin concentrations in women (AUC=0.656, 95% of 0.482–0.830, P=0.050), albumin concentrations (AUC=0.539, 95% CI of 0.114–0.964, P=0.792 in men; AUC=0.538, 95% CI of 0.367–0.710, P=0.620 in women) and total cholesterol levels (AUC=0.679, 95%CI of 0.560–0.790, P=0.220 in men; AUC=0.633, 95%CI of 0.468–0.799, P=0.094 in women) were poor to fair, showing that these biomarkers have limited diagnostic accuracy in elderly primary care patients. The AUC of haemoglobin concentration in men was good and statistically significant (AUC=0.863, 95% CI of 0.751–0.974, P=0.013). The sensitivity of the proposed cut-off value of 120 g/l was 50% and the specificity was 92%.

4 DISCUSSION

The current study focused on the ability of the serum biomarkers to detect malnutrition and nutritional risk. The malnutrition indicators associated with the serum biomarkers concentrations were also analysed. The results showed that the ability of ferritin, haemoglobin, albumin and total cholesterol to identify nutritional risk and malnutrition among elderly primary health care was limited.

Although the study produced by Cabrerizo et al. (26) described the relationship between hypoalbuminemia and malnutrition in clinically stable people, the research conducted by Kuzuya et al. (27) demonstrated that a cut-off value of 35 g/l cannot be used as a marker of malnutrition among older people, which is in line with the current study. Mean albumin concentrations were in the normal range for older adults, regardless of nutritional risk. Whether the relationship between serum albumin and disability in ADL is mediated through nutritional risk or the effects of physical inactivity on muscle-wasting is not well understood. Nevertheless, inadequate nutrition combined with impaired mobility could trigger inflammation, and therefore down-regulate protein synthesis, regardless of protein consumption (27), which was lower in the current study than recommended. Despite the recommendation to use albumin as a biomarker in geriatric evaluation in all healthcare settings (28), its value in distinguishing malnourished from well-nourished elderly people in primary healthcare settings appears to be very low.

Mean ferritin concentrations were not statistically higher among malnourished or “at risk” respondents compared to those who had normal nutritional status, and were within the optimal reference range for general adult populations. Our findings corroborate the study produced by Schreiber et al. (29) that showed no relationship between nutritional status and ferritin levels. A previous study has identified alterations in serum ferritin caused by chronic disease, alcohol consumption, inflammation, edentulism, multimorbidity, infection, decreasing sex hormone activity or other problems related to ageing (30), all of which may potentially influence elderly people’s nutritional status. While ferritin could be an indicator of overall nutrition and health, its contribution to the

precise diagnosis of malnutrition and nutritional risk has been shown to be weak.

Previous research showed a decrease in haemoglobin in malnutrition (11, 28), which is in line with the current study. Although the AUC for men was good, the AUC for women was poor. Haemoglobin is a useful and cost-effective biomarker of malnutrition in hospitalised elderly patients (11, 29), but its use in primary care does not appear to add very much to the assessment of nutritional risk.

The study produced by Kuzuya et al. proposed a cut-off value of 3.88 mmol/l for cholesterol (sensitivity 73%, specificity 50%) as a reflection of malnutrition (27). In the current study, despite the statistical difference in values between three categories of nutritional status, mean concentrations of total cholesterol were detected to be within the optimal to borderline reference range. The use of cholesterol in clinical practice as a single indicator of nutritional status would miss the identification of malnourished respondents and elderly people at risk of malnutrition (11).

Although in terms of energy and macronutrients, the study participants met or exceeded the recommendations, they consumed low amounts of micronutrients, such as vitamins C, D, and E, as well as minerals, which might have affected the results. Low micronutrient intake makes it imperative that primary care providers focus more on advising older individuals to select foods rich with micronutrients to ensure the proper balance of nutrients (31, 32).

This is the first study to analyse concentrations of serum biomarkers in relation to malnutrition among elderly primary care patients in Bosnia and Herzegovina. Elderly persons living in the community and nursing home residents over 65 years of age were enrolled in the study, making the sample heterogeneous and representative of older Bosnian adults. Standardised, validated and comprehensive instruments were used to assess nutritional status. There are several limitations to be discussed. The study was cross-sectional and did not evaluate nutritional status over a period of time. Owing to limited financial resources, four biomarkers were included and were only measured at one point in time. The high prevalence of high nutritional risk might have influenced the results. Longitudinal studies are required to analyse the response of biomarkers to nutritional interventions.

5 CONCLUSION

Although ferritin, haemoglobin, albumin and total cholesterol may be useful biomarkers of nutritional status, their accuracy in diagnosing malnutrition and nutritional risk among elderly primary healthcare patients is poor. An overview of our findings (high prevalence of high nutritional risk) also suggests the need to routinely assess nutritional status and screen for malnutrition among elderly primary care patients. Assessment needs to be comprehensive and to include anthropometric, functional, dietary and medical indicators. As family physicians are the gatekeepers of the healthcare system, and are overburdened by an ageing population and multimorbidity, it is vital for the assessment/screening instruments to be cost- and time-effective.

ACKNOWLEDGEMENTS

Special thanks to Dr Heather Keller, the author of SCREEN II, for permission to translate SCREEN II and use it in our research. We would like to thank Elizabeth Klaassen for the English language editing.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist in relation to this research.

FUNDING

The current study was supported by a grant awarded by the Ministry for Scientific and Technological Development, Higher Education and Information Society of the Republic of Srpska, Bosnia and Herzegovina, contract no. 19/6-020/961-113/1.

ETHICAL APPROVAL

All procedures performed in studies involving human participants were carried out in accordance with the ethical standards of the institutional and/or national research committee Ethics Committee of Faculty of Medicine Foca (No: 01-2-1) and the 1964 Helsinki Declaration and its later amendments, or with comparable ethical standards.

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