Int J Nutr Sci 2026;11(2):

International Journal of Nutrition Sciences

Journal Home Page: ijns.sums.ac.ir

Original Article

The Relationship between High-Protein Diets and Sarcopenia among Iranian Elderly Population

Ali Abesi[1], Marzieh Mahmoodi[2], Farimah Dehghani[3], Zainab Shateri[4], Zahra Sohrabi[5], Mehran Nouri[6*], Mohammad Hossein Dabbaghmanesh[7*]

1. Student Research Committee, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
2. Department of Nutrition, Faculty of Health and Nutrition, Bushehr University of Medical Sciences, Bushehr, Iran
3. Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
4. Department of Nutrition and Biochemistry, School of Medicine, Ilam University of Medical Sciences, Ilam, Iran
5. Department of Community Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
6. Infertility and Reproductive Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran
7. Endocrinology and Metabolism Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

ARTICLE INFO

Keywords:
High-protein
Diet
Sarcopenia
Elderly
Iran

Corresponding author:
Mehran Nouri, PhD;
Infertility and Reproductive Health Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran.
Tel: +98-9378542652
Email: mehran_nouri71@yahoo.com
Mohammad Hossein Dabbaghmanesh, PhD;
Endocrinology and Metabolism Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.
Tel: ????
Email: dabbaghm@sums.ac.ir
Received: January 29, 2026
Revised: April 24, 2026
Accepted: April 30, 2026

ABSTRACT

Background: Nutrition is crucial for boosting the performance, muscular power, and size of older adults. The current research's objective was to explore the link between the risk of sarcopenia and a high-protein diet score among Iranian elderly population.

Methods: Two groups of a case group of 80 elderly individuals and a control group of 80 elderly subjects aged 65 years or older in Iran were enrolled. The recommendations of the Asian Working Group for Sarcopenia were applied to diagnose sarcopenia. To assess dietary intake, a food frequency questionnaire with 168 items was applied. There were three distinct kinds of high-protein diets created. Using logistic regression, the link between the risk of sarcopenia and high-protein diet scores was analyzed.

Results: Each point rise in all high-protein diet scores (low-carbo, low-fat, and high-protein diet [odds ratio (OR)=0.638, 95% confidence interval (95%CI): 0.551-0.739; low-fat, high-carb, and high-protein diet: OR=0.856, 95%CI: 0.813-0.902; high-fat, low-carb, and high-protein diet: OR=0.828, 95%CI: 0.757-0.907)] was linked to a lower chance of developing sarcopenia in the crude model. However, in the adjusted models, no association was identified between and all high-protein diet scores and sarcopenia odds.

Conclusion: The current case-control study did not find any significant correlation between high-protein dietary intake and the risk of sarcopenia.

Please cite this article as: Abesi A, Mahmoodi M, Dehghani F, Shateri Z, Sohrabi Z, Nouri M, Dabbaghmanesh MH. The Relationship between High-Protein Diets and Sarcopenia among Iranian Elderly Population. Int J Nutr Sci. 2026;11(2):
doi:

Introduction

Sarcopenia is a status commonly affecting the older adults, marked by a gradual decline in function and muscle mass, which can result in fractures, reduced performance, and even death (1). A sedentary lifestyle, chronic diseases, and malnutrition are certain risk factors for sarcopenia. In this disease, complex pathophysiological mechanisms are involved, such as inflammation, changes in hormones, oxidative stress, mitochondrial dysfunction, microvascular changes, and lipotoxicity (1). Sarcopenia becomes more common as people become older and affects 11-50% of those who are 80 years and older and 5-13% of people between the ages of 60 and 70 years (2). Women, the elderly, those with other chronic diseases, and those who are underweight are at a greater risk of developing sarcopenia and the negative consequences associated with it (3). However, there is a significant decline in food consumption as people become older (4), and elderly individuals are at risk of malnutrition (5, 6).

Nutrition is crucial for performance, muscular mass, and strength in the elderly and even at cellular level (7, 8). Nutrition is a factor that can be changed and may be used to promote healthy and active aging (9, 10). Among the nutritional factors that are effective in sarcopenia, low intake of protein and calories and deficiency in vitamin D can be mentioned (11). However, in elderly, consuming protein above the recommended dietary allowance (RDA) of 0.8 g/kg daily has been suggested as an approach for maintaining muscle mass (12).

Dietary protein intake is demonstrated to be a possible determinant in cellular and muscular health since protein synthesis needs an adequate substrate, and muscle breakdown is a known consequence of protein malnutrition (13, 14). In this direction, the European Society for Clinical Nutrition and Metabolism (ESPEN) proposed 1-1.3 g/kg daily for elderly people (15, 16). The sources of dietary protein can have different effects on function and muscular mass (17). Animal protein is more effective than plant protein because of its essential amino acid profiles and higher digestibility (17, 18). On the other hand, fiber and antioxidants from plant protein sources can help lower inflammation in the body and potentially improve muscle size (19, 20). The results of previous studies are conflicting regarding which protein sources are more effective in sarcopenia (21, 22).

Given the rising number of elderly individuals, it is essential to prevent sarcopenia and maintain muscle mass in this population (23); it is necessary to conduct more studies on this issue. Based on our information, no research has assessed the link between sarcopenia risk and a high-protein diet score in elderly individuals. Therefore, current research's objective was to explore the link between a high-protein diet score and sarcopenia odds among elderly Iranian population.

Materials and Methods

This case-control research was currently conducted on Iranian elderly individuals based on a previous study (24). Participants were selected based on the available cases in Shiraz healthcare centers at the beginning of this study enrolling a total of 501 elderly individuals. Out of them, 104 patients were diagnosed with sarcopenia by skilled physicians. The selected case group was consisted of 80 elderly adults. Additionally, the same method was used to choose 80 elderly individuals without sarcopenia as the control group. This study was approved by the Medical Research and Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.SCHEANUT.REC.1402.121). All participants read and signed the informed consent form.

Inclusion criteria were having no history of acute organ and cognitive failure, being physically active, living independently, and being older than 65 years. Those who chose to be withdrawn from the research or who completed insufficient questionnaires were excluded. A simple checklist was applied to gather demographic data, including smoking status, educational level, age, and sex. To evaluate the physical activity of elderly individuals, a validated international physical activity questionnaire (IPAQ) was used as mentioned before (25). The consent form was completed by all subjects too.

Following the recommendations of the Asian Working Group for Sarcopenia (AWGS), people with sarcopenia were those who had low physical activity, reduced muscular mass or strength. Meanwhile, severe sarcopenia was marked by a decline in physical activity, diminished muscle mass, and a loss of muscular power (24, 26). Using a bioelectrical impedance analysis (South Korea), body composition was assessed. The skeletal muscle mass index (SMI) was determined using a formula. An SMI of <5.7 and <7 kg/m^2 in women and men, respectively, indicated sarcopenia (24, 26).

Over a 4-meter distance, the normal gait speed (GS) of participants was measured to assess their muscular performance. Low physical function was determined by GS<0.8 m/s (24, 26). Muscle strength was assessed by handgrip strength (HGS) applying a hydraulic hand dynamometer (Korea). The maximum reading from three hand dynamometer squeezes was measured while the subject was sitting. A strength of muscle <18 kg for women and a strength of muscle <26 kg for male indicated decreased HGS (24, 26). The participants' dietary intake over the previous year was assessed using a validated and reliable 168-item Food Frequency Questionnaire (FFQ), which evaluated their yearly, monthly, weekly, or daily intake (27). All items were changed to grams, and finally, using Nutritionist IV software, all nutrients and energy intake were determined (28, 29).

To evaluate the consumption of protein, carbohydrates, and fats, the contribution of each of these macronutrients to energy intake was calculated and classified into deciles. For each decile, a point of one to ten was taken for diets high in protein, carbs, and fat, respectively. Furthermore, a score of 10 to 1 was taken for each decile in low-fat and low-carb diets. The three types of high-protein diets that were then developed were (1) a diet that was low in carbs and fat but high in protein; (2) a diet that was low in carbs but high in fat and protein; and (3) a diet that was low in fat but high in carbs and protein.

Using SPSS software (version 24, Chicago, IL, USA), the statistical analysis in the current research was carried out. The Mann-Whitney U test and independent samples T-test were utilized to analyze the relationship between the variables. Applying the chi-square test, the relationship between categorical variables was assessed. The link between the risk of sarcopenia and high-protein diet scores was analyzed using logistic regression, and the adjusted model controlled for the variables of smoking history, physical activity, fat intake, protein intake, energy intake, and age. Significance was ascertained with a two-sided *p* value<0.05.

Results

The research population features between the sarcopenic and healthy populations were illustrated in Table 1. Body mass index (BMI), weight, age, SMI, muscle strength, and GS were significantly different between the sarcopenic and healthy populations. Additionally, compared to the sarcopenic group, the control group had significantly greater consumption of plant and animal protein, protein, energy, fat, carbohydrate, and all high-protein diets ($p<0.001$ for all). Table 2 illustrates the link between the risk of sarcopenia and high-protein dietary ratings. In the crude model, each unit rise in all high-protein diet scores as low-fat, low-carb, and high-protein diet score [odds ratio (OR)=0.638, 95%confidence interval (95%CI): 0.551–0.739]; low-fat, high-carb, and high-protein diet score (OR=0.856, 95%CI: 0.813-0.902); low-carb, high-fat, and high-protein diet score (OR=0.828, 95%CI: 0.757-0.907) was linked to a reduction probability of sarcopenia. But after accounting for physical activity, protein intake, smoking history, fat intake, energy intake, and age, the probability of sarcopenia was not correlated to all high-protein diet scores ($p>0.05$).

Table 1: The study population characteristics among the sarcopenic and healthy populations.

Variable	Case (n=80)	Control (n=80)	Total population (n=160)	*P* value
Age (years)[1]	70.0 (67.0-75.0)	68.0 (65.0-71.0)	69.00 (66.00-72.75)	0.001
Weight (kg)[2]	59.62±9.21	78.05±9.05	68.84±12.97	<0.001
BMI (kg/m^2)[2]	24.5±4.1	29.2±3.8	26.85±4.61	<0.001
Muscle strength (kg)[1]	16.0 (11.0-21.7)	50.8 (41.0-65.2)	25.50 (16.00-50.83)	<0.001
SMI (kg/m^2)[1]	6.1 (5.4-6.8)	7.9 (7.4-8.3)	7.03 (6.04-7.94)	<0.001
Gait speed (m/second)[2]	0.70±0.10	1.00±0.95	0.85±0.69	0.007
Physical activity (MET.hour/week)[1]	429.0 (0.0-1020.7)	462.0 (0.0-1386.0)	462.0 (0.0-1386.0)	0.650
Gender, female, %[3]	36 (45.0)	36 (45.0)	72 (45.0)	1.000
Income level, higher than 6 million in month, %[3]	11 (13.8)	21 (26.3)	32 (20.0)	0.127
Education, under diploma, %[3]	52 (65.0)	49 (51.2)	101 (63.1)	0.743
Smoking history, no, %[3]	61 (76.2)	58 (72.5)	119 (74.4)	0.718
Energy intake (kcal/day)[2]	1329.2±472.9	1861.9±450.4	1595.5±532.3	<0.001
Protein intake (g/day)[2]	44.46±15.27	65.37±18.61	54.91±19.94	<0.001
Plant protein intake (g/day)[2]	21.96±9.20	32.68±11.98	27.32±11.93	<0.001
Animal protein intake (g/day)[2]	22.50±10.05	32.68±10.64	27.59±11.51	<0.001
Fat intake (g/day)[2]	39.17±13.33	49.71±12.50	44.44±13.92	<0.001
Carbohydrate intake (g/day)[2]	210.55±94.97	304.10±87.47	257.33±102.39	<0.001
Low-fat, low-carbohydrate, and high-protein diet score[2]	14.98±2.39	18.01±2.51	16.50±2.88	<0.001
Low-fat, high-carbohydrate, and high-protein diet score[2]	12.26±7.42	20.73±6.64	16.50±8.21	<0.001
High-fat, low-carbohydrate, and high-protein diet score[2]	15.17±3.56	17.83±3.91	16.50±3.96	<0.001

MET: Metabolic equivalent of task; BMI: Body mass index; kg: Kilogram; m: Meter; SMI: Skeletal muscle mass index; kcal: Kilocalorie; g: Gram. [1]Using the Mann-Whitney U test for abnormal continuous variables, the values were presented as medians (25th-75th percentiles). [2]Using independent samples T-test for normal continuous variables, the values are mean±SD. [3]Using chi-square test for categorical variables, the values are frequencies (percentages).

Table 2: Association between high-protein diets score and odds of sarcopenia.

Variable	Crude model		Adjusted model	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Low-fat, low-carbohydrate, and high-protein diet score	0.638 (0.551-0.739)	<0.001	0.895 (0.396-2.020)	0.789
Low-fat, high-carbohydrate, and high-protein diet score	0.856 (0.813-0.902)	<0.001	0.767 (0.569-1.034)	0.082
Low-carbohydrate, high-fat, and high-protein diet score	0.828 (0.757-0.907)	<0.001	0.891 (0.585-1.356)	0.590

OR: Odds ratio; CI: Confidence interval. Significant values were shown in bold. These values are odds ratios (95% CIs). Obtained from logistic regression by enter method. Adjusted for age, energy intake, protein intake, fat intake, physical activity, and smoking history.

Discussion

We assessed the association between the odds of sarcopenia and adherence to three high-protein dietary patterns in the elderly in our case-control study. In crude models, higher scores of the low-carb, high-fat, and high-protein diet; the low-carb, low-fat, and high-protein diet; and the low-fat, high-carb, and high-protein diet were associated with a significant decline in sarcopenia odds. No strong correlation between the odds of sarcopenia and high-protein dietary patterns was found after controlling for possible confounding variables.

In line with our findings, a three-year prospective longitudinal cohort investigation did not suggest any significant link between the risk of sarcopenia and following a high-protein diet (30). Unlike our 10-scale scoring system, a borderline of 1 g per kg body weight was considered in the mentioned study for categorizing dietary patterns as high- or low-protein diets. A case-control study also did not observe any significant decline in the odds of sarcopenia with greater grams of daily protein consumption or higher percentages of energy from protein (31). However, despite our results, this study showed a 6% decrease in sarcopenia risk in individuals with greater protein consumption per kg of body weight. A prospective cross-sectional study of 250 participants also did not observe any significant difference in sarcopenia risk with different values of daily protein intake (32).

Contrary to our findings, a large prospective cohort study on 986 older adults revealed that participants who consumed >1.2 g of protein per kg of body weight each day had a marked decrease in their score for sarcopenia risk (33). The quantity of protein consumption linked to lowering sarcopenia risk in the mentioned study (80 g/d) was almost twice the average protein intake among our participants (44 g/d). Another longitudinal study observed a direct relationship between the participants' protein consumption and their lean mass too (34). The average protein consumption was 70 g/d in that study, almost 30 g/d greater than the average protein intake in our investigation. A three-year prospective cohort study revealed a strong correlation between not meeting the recommended protein consumption and a notable decline in lean body mass too (35).

In the present investigation, there was no link between protein consumption and sarcopenia odds. The protein intake among the case group of the current study (44.4 g/day) was considerably lower than that of prior studies that demonstrated a correlation between lean body mass and protein consumption (33, 36). This level of protein consumption was also below the current RDAs for protein consumption (0.8 g per kg of body weight), which might explain the non-significant link between high-protein diets and sarcopenia risk in the current research. Moreover, some studies claimed that even the RDAs of protein were not sufficient for maintaining lean mass since they were based on nitrogen balance (37). In addition, half of the protein amount consumed in the current study was from plant sources, which may impede the growth of lean body mass and the prevention of sarcopenia due to the difficulty in their digestion and in providing digestible indispensable amino acids (38).

The present study's main strengths were the participation of both men and women, the application of validated questionnaires for assessing dietary intakes and physical activity of the participants during face-to-face interviews, the conducting of BIA for measuring body composition, the consideration of the three important factors of reduced physical activity, muscle weakness, and poor muscle mass for evaluating sarcopenia, and the control of the results for a variety of covariates.

However, some limitations might also be observed in the current research. First, the study's small sample size means that its conclusions may not apply to the whole Iranian population. Second, the case-control design of the current research might not be able to prove the causal relationship between dietary protein and sarcopenia risk (39). Third, recall biases might be unavoidable because of the characteristics of case-control studies and the fact that we carried out questionnaires to assess demographic characteristics and dietary intakes, especially among the case group (40). We controlled the results for various covariates, while some potential residual confounders might still influence our findings.

Conclusion

The current case-control research did not suggest a significant correlation between sarcopenia odds and following high-protein dietary patterns. To confirm these results, more longitudinal and clinical trial studies are necessary.

Acknowledgment

We sincerely thank all field investigators, staff, and participants of the present study.

Funding

Not applicable.

Authors' Contribution

AA, FD, ZS and MN contributed to writing the first draft. MM contributed to data collecting. MN and ZS contributed to all data and statistical analysis, and interpretation of data. ZS and MHD contributed to the research concept, supervised the work and revised the manuscript. All authors read and approved of the final manuscript.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1 Cruz-Jentoft AJ, Sayer AA. Sarcopenia. *Lancet*. 2019;393:2636-46. DOI: 10.1016/S0140-6736(19)31138-9. PMID: 31171417.

2 Morley J. Sarcopenia: diagnosis and treatment. *J Nutr Health Aging*. 2008;12:452-6. DOI: 10.1007/BF02982705. PMID: 18615226.

3 Petermann-Rocha F, Chen M, Gray SR, et al. Factors associated with sarcopenia: A cross-sectional analysis using UK Biobank. *Maturitas*. 2020;133:60-7. DOI: 10.1016/j.maturitas.2020.01.004. PMID: 32005425.

4 Wakimoto P, Block G. Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. *J Gerontol A Biol Sci Med Sci*. 2001;56:65-80. DOI: 10.1093/gerona/56.suppl_2.65. PMID: 11730239.

5 Agarwal E, Miller M, Yaxley A, et al. Malnutrition in the elderly: a narrative review. *Maturitas*. 2013;76:296-302. DOI: 10.1016/j.maturitas.2013.07.013. PMID: 23958435.

6 Andisheh-Tadbir A, Mehrabani D, Heydari St. Sociodemographic And Etiological Differences Of Head And Neck Squamous Cell Carcinoma In Young And Old Patients In Southern Iran. *J Craniofac Surg*. 2010;21:126-8. DOI: 10.1097/SCS.0b013e3181c46c10. PMID: 20072017.

7 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. DOI: 10.1016/j.clnu.2017.08.016. PMID: 28927897.

8 Mehrabani D, Masoumi SJ, Masoumi AS, et al. Role of diet in mesenchymal stem cells' function: a review. *Int J Nutr Sci*. 2023;8:9-19. DOI: 10.30476/IJNS.2023.97788.1221.

9 Calvani R, Miccheli A, Landi F, et al. Current nutritional recommendations and novel dietary strategies to manage sarcopenia. *J Frailty Aging*. 2013;2:38-53. PMID: 26082911.

10 Chen LK, Arai H, Assantachai P, et al. Roles of nutrition in muscle health of community-dwelling older adults: evidence-based expert consensus from Asian Working Group for Sarcopenia. *J Cachexia Sarcopenia Muscle*. 2022;13:1653-72. DOI: 10.1002/jcsm.12981. PMID: 35307982.

11 Ziaaldini MM, Marzetti E, Picca A, et al. Biochemical pathways of sarcopenia and their modulation by physical exercise: a narrative review. *Front Med*. 2017;4:167. DOI: 10.3389/fmed.2017.00167. PMID: 29046874.

12 Coelho-Junior HJ, Calvani R, Azzolino D, et al. Protein intake and sarcopenia in older adults: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2022;19:8718. DOI: 10.3390/ijerph19148718. PMID: 35886571.

13 Beasley JM, Shikany JM, Thomson CA. The role of dietary protein intake in the prevention of sarcopenia of aging. *Nutr Clin Pract*. 2013;28:684-90. DOI: 10.1177/0884533613507607. PMID: 24163319.

14 Homayoun M, Mehrabani D, Edalatmanesh MA, et al. The Role of Lithium Chloride in Nutrition and Stem Cell Growth Kinetics: A Review. *Int J Nutr Sci*. 2021;6:6-13. DOI: 10.30476/IJNS.2021.88801.1104.

15 Nowson C, O'Connell S. Protein requirements and recommendations for older people: a review. *Nutrients*. 2015;7:6874-99. DOI: 10.3390/nu7085311. PMID: 26287239.

16 Deutz NE, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: recommendations from the ESPEN Expert Group. *Clin Nutr*. 2014;33:929-36. DOI: 10.1016/j.clnu.2014.04.007. PMID: 24814383.

17 Gorissen SH, Witard OC. Characterising the muscle anabolic potential of dairy, meat and plant-based protein sources in older adults. *Proc Nutr Soc*. 2018;77:20-31. DOI: 10.1017/S002966511700194X. PMID: 28847314.

18 Mahmoodi R, Daryanoosh F, Kasharafifard S, et

al. Effect of exercise on serum adiponectin and lipoprotein levels in male rat. *Pak J Biol Sci*. 2014;17:297-300. DOI: 10.3923/pjbs.2014.297.300. PMID: 24783818.

19 Stoodley IL, Williams LM, Wood LG. Effects of Plant-Based Protein Interventions, with and without an Exercise Component, on Body Composition, Strength and Physical Function in Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Nutrients*. 2023;15:4060. DOI: 10.3390/nu15184060. PMID: 37764843.

20 Daryanoosh F, Sharifi GR, Jafari M, et al. The effect of running exercise and calcium supplementation on femoral bone strength in ovariectomized rats. *Global Vet.* 2013;11:694-700. DOI: 10.5829/idosi.gv.2013.11.6.81189.

21 Lim MT, Pan BJ, Toh DWK, et al. Animal protein versus plant protein in supporting lean mass and muscle strength: a systematic review and meta-analysis of randomized controlled trials. *Nutrients*. 2021;13:661. DOI: 10.3390/nu13020661. PMID: 33670701.

22 Gazzani D, Zamboni F, Spelta F, et al. Vegetable but not animal protein intake is associated to a better physical performance: A study on a general population sample of adults. *Food Nutr Res.* 2019;63. DOI: 10.29219/fnr.v63.3422. PMID: 31565042.

23 Roubenoff R. Sarcopenia and its implications for the elderly. *Eur J Clin Nutr*. 2000;54:S40-S7. DOI: 10.1038/sj.ejcn.1601024. PMID: 11041074.

24 Nasimi N, Dabbaghmanesh MH, Sohrabi Z. Nutritional status and body fat mass: Determinants of sarcopenia in community-dwelling older adults. *Expe Gerontol.* 2019;122:67-73. DOI: 10.1016/j.exger.2019.04.009. PMID: 31022445.

25 Moghaddam MB, Aghdam FB, Jafarabadi MA, et al. The Iranian Version of International Physical Activity Questionnaire (IPAQ) in Iran: content and construct validity, factor structure, internal consistency and stability. *World Appl Sci J.* 2012;18:1073-80. DOI: 10.5829/idosi.wasj.2012.18.08.754.

26 Chen LK, Liu LK, Woo J, et al. Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. *J Am Med Dir Assoc*. 2014;15:95-101. DOI: 10.1016/j.jamda.2013.11.025. PMID: 24461239.

27 Mirmiran P, Esfahani FH, Mehrabi Y, et al. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. *Public Health Nutr.* 2010;13:654-62. DOI: 10.1017/S1368980009991698. PMID: 19807937.

28 Ghaffarpour M, Houshiar-Rad A, Kianfar H. The manual for household measures, cooking yields factors and edible portion of foods. Tehran: Nashre Olume Keshavarzy. 1999;7:42-58.

29 Nutritionist I. N-squared computing. Silverton: Nutritionist IV. 1998.

30 Granic A, Mendonça N, Sayer AA, et al. Effects of dietary patterns and low protein intake on sarcopenia risk in the very old: The Newcastle 85+ study. *Clin Nutr*. 2020;39:166-73. DOI: 10.1016/j.clnu.2019.01.009. PMID: 30709690.

31 Verlaan S, Aspray TJ, Bauer JM, et al. Nutritional status, body composition, and quality of life in community-dwelling sarcopenic and non-sarcopenic older adults: A case-control study. *Clin Nutr*. 2017;36:267-74. DOI: 10.1016/j.clnu.2015.11.013. PMID: 26689868.

32 Rahman R, Wilson BP, Paul TV, et al. Prevalence and factors contributing to primary sarcopenia in relatively healthy older Indians attending the outpatient department in a tertiary care hospital: A cross-sectional study. *Aging Med (Milton)*. 2021;4:257-65. DOI: 10.1002/agm2.12186. PMID: 34964006.

33 Montiel-Rojas D, Nilsson A, Santoro A, et al. Fighting Sarcopenia in Ageing European Adults: The Importance of the Amount and Source of Dietary Proteins. *Nutrients*. 2020;12:3601. DOI: 10.3390/nu12123601. PMID: 33255223.

34 Houston DK, Nicklas BJ, Ding J, et al. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. *Am J Clin Nutr.* 2008;87:150-5. DOI: 10.1093/ajcn/87.1.150. PMID: 18175749.

35 Scott D, Blizzard L, Fell J, et al. Associations between dietary nutrient intake and muscle mass and strength in community-dwelling older adults: the Tasmanian Older Adult Cohort Study. *J Am Geriatr Soc*. 2010;58:2129-34. DOI: 10.1111/j.1532-5415.2010.03147.x. PMID: 21054294.

36 Houston DK, Nicklas BJ, Ding J, et al. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. *Am J Clin Nutr*. 2008;87:150-5. DOI: 10.1093/ajcn/87.1.150. PMID: 18175749.

37 Campbell WW, Trappe TA, Wolfe RR, et al. The recommended dietary allowance for protein may not be adequate for older people to maintain skeletal muscle. *J Gerontol A Biol Sci Med Sci.* 2001;56:M373-80. DOI: 10.1093/gerona/56.6.m373. PMID: 11382798.

38 Reid-McCann RJ, Brennan SF, McKinley MC, et al. The effect of animal versus plant protein

on muscle mass, muscle strength, physical performance and sarcopenia in adults: protocol for a systematic review. *Syst Rev*. 2022;11:64. DOI: 10.1186/s13643-022-01951-2. PMID: 35418173.

39 Lewallen S, Courtright P. Epidemiology in practice: case-control studies. *Community Eye Health*. 1998;11:57-8. PMID: 17492047.

40 Tenny S, Kerndt CC, Hoffman MR. Case Control Studies. StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2024, StatPearls Publishing LLC.; 2024. PMID: 28846237.