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Correlation of Dietary Protein Intake with Body Composition and Physical Status in Patients with Knee Osteoarthritis

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ABSTRACT

Background & Objective: Little is known about the association between dietary protein intake and clinical manifestations in osteoarthritis (OA) patients. We aimed to determine the correlation between dietary protein intake and pain severity, functional status, and body composition indices in patients with knee OA.

Materials & Methods: This cross-sectional study was performed on 220 OA patients, staged I to Ⅲon Kellgren and Lawrence scale. Patients were selected randomly via cluster sampling method from the health centers of Tabriz between October 2017 and October 2018. We estimated the participants' protein intakes using a semi-quantitative food frequency questionnaire. Western Ontario and McMaster Index (WOMAC) was used to measure the functional status. We used the Visual Analogue Scale to measure pain severity. A bioelectric impedance device measured the patients' body composition.

Results: Total dietary protein intake was 55.36±24.14 grams per day. Higher dietary total and animal-based protein intakes were associated with lower pain severity. There were reverse correlations between dietary protein intakes (total and animal-based) with the physical disability according to WOMAC total, WOMAC pain, and WOMAC stiffness scores in the subset of patients who didn't meet the 75 percent of recommended dietary allowance. In these patients, higher total, plant-based, and animal-based protein intakes correlated with WOMAC functional scores. Higher total and animal-based protein intakes were associated with higher soft lean and lean body mass in women.

Conclusion: Dietary protein intake needs to improve in knee OA patients, and dietary protein intake might be an intermediation objective in these patients.

Keywords: Body composition, Dietary protein, Functional status, Knee osteoarthritis, Pain

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Introduction

Osteoarthritis (OA) is the most common type of arthritis in humans, which is increasing in developed and developing countries by changing lifestyles and obesity as well as the rise of the aged population (1). The most common form of OA is in the knees because bearing body weight and is subject to direct pressure. The prevalence of the disease in women is higher than that of men and increases with age (2).

Healthy nutrition is one of the bases for developing a healthy and productive population. Today, the association of nutrition and food choices with community health is fully understood. As growing older, there is a change in the nutritional needs of individuals. Much research has been carried out on the prevalence of nutritional disorders and malnutrition among the elderly with different conditions (free-living, in a nursing home, or in a hospital). Mokhber *et al.* (3) showed that the prevalence of malnutrition in free-living elderly was 11.5%, and the percentage of elderly with an extraordinary risk of malnutrition was 44%. Cai *et al.* (4) reported that the diet of the elderly is based on their health status, and individuals with chronic illnesses tend to consume more vegetable-based foods than meat.

Some studies have identified protein as the essential nutrient in the elderly (5). Nowadays, the recommended daily allowance (RDA) has been set at 0·83 g per kg of body weight per day of good quality proteins for healthy young adults (6). Animal-based foods are considered the primary source of high-quality protein (7). Today, there is a developing body of evidence that this RDA is insufficient for the elderly. The protein need is increased in the elderly to preserve muscle mass and functionality

(8). Protein intake above the recommended levels can reduce the loss of muscle tissue that occurs chronically in the elderly (9). Meanwhile, higher protein intake in the elderly is associated with a reduction in mortality, suggesting that a protein intake of at least 10% of the daily calorie in the elderly is necessary to maintain muscle mass (10). Because of the undesirable environmental effect of intensive animal production and owing to the health benefits of eating fruit, vegetables, and grains, nutritional guidelines in some countries tend to recommend increasing plant protein consumption (11).

The interest and attention to low body mass and sarcopenia increased in the last decades. Recently, the relationship between body mass index (BMI) and OA has been highlighted in studies. Anthropometric measurements such as BMI, hip circumference, and waist-to-hip ratio (WHR) are applied to investigate the correlation between obesity and radiographic OA (12). On the other hand, obesity, commonly defined as BMI ≥ 30 kg/m^2, does not consider body composition. Other indices are applied to distinguish fat and lean mass to describe overweight conditions compriseing lean body mass (LBM), the mass of body fat (MBF), and soft lean mass (SLM).

The impact of weight loss on pain and bodily function is comprehended in OA patients, but less recognized is the evidence that diet quality may affect pain and function. Knee OA is more common in obese individuals with low LBM than those without low LBM (13). Many studies have shown that skeletal muscle mass prevents the occurrence of OA or established a positive correlation between muscle mass and the width of joint space (14). However, the relation between body composition and symptoms of OA is not clearly defined.

On the other hand, dietary protein improves muscle protein synthesis and prevents muscle protein breakdown, which improves LBM over time (14). Knee OA patients may require even greater protein consumption than RDA since they are mostly older adults, report lower physical activity, have chronic low-grade inflammation, and are predisposed to develop anabolic resistance (15). These considerations propose that the correlation between dietary protein intake, body composition indices, and pain and disability in knee OA patients are not necessarily the same as in older adults.

The correlation between daily dietary protein intake, body composition indices, and clinical symptoms in knee OA is unknown. Caregivers and patients have queries regarding nutritional necessities and dietary supplements in clinical practice. Considering the high interest, few studies have focused on dietary intake in patients with knee OA. The objective of this study was to examine the correlation between dietary protein intake and the indicators of body composition, pain, and functional status in patients with knee OA.

Materials and Methods

This cross-sectional descriptive study was performed on the target population including all patients with knee OA in the health centers of Tabriz University of Medical Sciences.

The data collection period was one year between October 2017 and October 2018. The cluster sampling method was used in the health centers of Tabriz University of Medical Sciences. Tabriz has 65 health centers, with the characteristics of all covered individuals and underlying medical problems, telephone numbers, and addresses at the center. The researcher randomly selected the proportion of people with knee OA covered by each center. Patients were contacted by telephone, a brief description of the goals and method of carrying out the research was explained and, if they were willing to participate in the study, they were asked to be present at the chosen time in the health facility. In a meeting, the objectives of the study were fully elaborated and the study criteria were examined, and informed consent was signed by all qualified subjects.

The food frequency questionnaire (FFQ) used in the present study divides the food into 22 groups. Ten individuals per variable are sufficient according to the making the sample size. Therefore, the sample number was 220 (16).

The inclusion criteria were people, male or female, 40 to 75 years old; knee OA consistent with American College of Rheumatology (ACR) criteria; radiological score: stage I to Ⅲon Kellgren and Lawrence scale; regular use of painkillers [paracetamol, oral non-steroidal anti-inflammatory drugs (NSAIDs), and topical NSAID (cream/gel/patch)], at least once a day. The exclusion criteria were receiving less than 800 and more than 4200 calories daily, following a particular food pattern due to medical or other reasons, other inflammatory diseases such as rheumatoid arthritis, joint infections, history of knee injections in the last six months, taking corticosteroid medications during the previous month, use of opioid-containing medication and receiving non-pharmacological pain management methods (e.g., physiotherapy) during the previous six months. The dietary intakes were obtained using an FFQ according to the consumption frequency of each food group throughout the past year, on a daily, weekly, or monthly basis. Among the different approaches that measure dietary intake, the FFQ has been suggested as the most frequent and suitable tool to get the usual and long-term food consumption in epidemiological investigations. The FFQ comprises a list of foods and beverages with response groupings to show the typical frequency of intake over the past year. The standard, 168-item modified semi-quantitative FFQ has been used in another study and confirmed for validity and reliability in the Iranian population (17). A trained medical student completed the FFQ as the interviewer. We converted each food item frequency to a gram per day based on the measurement of household Iranian foods. Then each food and drink was encoded and entered in Nutritionist Ⅳ Software (First Databank, San Bruno, Calif., USA) modified for Iranian foods to assess the amount of energy and nutrients. Animal-based protein intake was estimated by summing up the protein content of red meat, poultry, dairy products, eggs, processed meat, and fish. Plant-based protein intake was measured by summing up the protein contents of grain, legumes, and nuts.

We measured the body weight without shoes and weighty clothing by a digital scale (Seca, Hamburg, Germany) to the nearest 0.1 kg. Height without shoes was measured by a non-stretched tape measure (Seca, Hamburg, Germany) to the nearest 0.1 cm. Body Mass Index (BMI) was calculated as the person's weight in kilograms divided by the square of height in meters. BMI was categorized into under-weight (<18.50 kg/m2), normal-weight (18.50–24.99 kg/m2), overweight (25.00–29.99 kg/m2), and obese (≥30.00 kg/m2).

Body Composition Analysis

One of the most suitable methods for measuring anthropometric indices is the use of a fast and non-invasive method of electrical impedance analysis (BIA) which, with more precision and relatively less cost, can quickly provide comprehensive information on body tissue constituents. Bioelectrical impedance was measured using the InBody270 scale, with participants standing without shoes on the analyser's footpads, and holding its handles. LBM, SLM, and MBF were measured.

The Persian version of the International Physical Activity Questionnaire (IPAQ) was used to assess physical activity. The total physical activity of a person in the last week is measured in terms of MET-minutes /week. In this study, the following criteria were used to classify the physical activity of the subjects: Intense physical activity: seven days a week or most days of the week, each combination of light or moderate and walking, which will total at least 3000, MET-days per week; Moderate physical activity: 5 days a week or most days of the week each combination of light or moderate and walking; which will total at least 600, MET-days per week, Light physical activity: the person does not report any activity or the reported physical activity does not have criteria for intense or moderate physical activity. The validity and reliability of the Persian version of the questionnaire have been confirmed **(18)**.

Western Ontario and McMaster Index (WOMAC) is one of the most commonly used instruments to measure the functional status and pain associated with OA in the lower extremities. This index has three subscales: WOMAC pain (5 items), WOMAC physical function (17 items), and WOMAC stiffness (2 items) consisting of 24 questions. Each item was scored on a 5-point scale; the higher the score, the worse the symptoms. The Persian version of the WOMAC index with proven validity and reliability was used **(19)**.

The visual Analogue Scale (VAS) is a tool for measuring pain severity in patients with OA. The VAS instrument is a graded ruler from 0 to 10, in which the patient shows the lowest to the highest limit on the ruler, depending on the severity of the pain.

Statistical analysis

We documented the name, dosage, and frequency of pain medications.

In analytical statistics, the Chi-2 test (precise test in low samples) was used for qualitative data and independent t-test (Mann-Whitney, if one-way independent t-test is not presupposed), and one-way ANOVA (Kruskal Wallis, in the case of non-setting-the-one-way-ANOVA tests) was used for quantitative data. Energy-adjusted protein intake was calculated using of the residuals from the regression model, with absolute protein intake as the dependent variable and total energy intake as the independent variable. The Spearmen correlation coefficient was used to determine the correlation between body composition and daily dietary protein intakes. The covariance analysis test was used to control confounding factors if needed. The significance level in all tests was considered 0.05%, and SPSS software 17 was used for analysis.

Ethical considerations

At the beginning of the study, the objectives of the design and method were explained in detail for each individual, and written informed consent was obtained from all participants. The subjects could exit the study when they wanted for no reason. No additional costs, complications, or interventions were imposed on patients, and patients were not deprived of their routine therapies. The study is reported according to the STROBE criteria. The protocol has been discussed and approved at the 225th session of the Ethics Committee of the Tabriz University of Medical Sciences (IR.TBZMED.REC.1395.1290).

Results

In this study, 310 patients with knee OA were evaluated to investigate the association between dietary protein and body composition analysis, pain, and functional status. Forty-three patients refuse to participate in the study. Forty-seven patients didn't meet the eligibility criteria.

We studied 68 males (30.91%) and 152 females (69.09%) with an average age of 56.89 ± 9.45 years. Table 1 shows the demographic findings of the participants.

The total adjusted protein intake in the participant was 55.36±24.14 grams (0.70±0.31 grams per kg weight) per day, of which 14.96±16.45 grams (19.37 ± 27.62%) was plant protein. One hundred and fifty-four participants (70 %) didn't meet the RDA for protein intake, of which 100 patients (45.4%) didn't meet the 75 % of RDA for protein intake. Men consumed more protein than women (69.70±27.12 vs. 49.11±19.72 g / day, $p<0.001$). However, the dietary animal based/plant-based protein ratio was significantly higher in women than in men ($p=0.007$).

Table 1. **General characteristics of participants (n = 220)**

Variable	Group	Frequency	Percentage
Age (years)		56.59±9.45	
Sex	Male	68	30.91
	Female	152	69.09
BMI(kg/m^2)		30.77±5.09	
	Normal (<- 24.9)	19	8.76
	Overweight (25 - 29.9)	78	35.94
	Obese (> - 30)	120	55.30
Education	Illiterate/ Primary school	107	48.64
	High school	71	32.27
	Higher education	42	19.09
Employment	Unemployed	115	52.27
	Employee	70	31.82
	Retired	35	15.91
Involved side	Right	43	19.55
	Left	75	34.09
	Both	102	46.36
Genu valgum	No	187	85.78
	Yes	31	14.22
Genu varum	No	167	75.91
	Yes	53	24.09
Physical activity	Mild	197	89.54
	Moderate	23	10.45
Chronic disease	Hypertension	44	20.00
	Hypothyroidism	12	4.45
	Diabetes type Ⅱ	10	4.55
	Respiratory disease	7	3.18
	Renal Disease	2	0.91
	Hepatic Disease	1	0.45
	Immunodeficiency Disease	1	0.45
Pain management medication	Diclofenac at least 50 mg/day	31	14.09
	Ibuprofen at least 200 mg/day	29	13.18
	Naproxen at least 500 mg/day	33	15.00
	Piroxicam at least 10 mg/day	2	0.93
	Meloxicam at least 7.5 mg/day	5	2.27
	Celecoxib at least 100 mg/day	25	11.36

Variable	Group	Frequency	Percentage
	Acetaminophen at least 500 mg/day	50	22.72
	Acetaminophen + Diclofenac	29	13.18
	Acetaminophen + Celecoxib	16	7.27
WOMAC total		42.96±14.60	
WOMAC pain		8.52±3.13	
WOMAC stiffness		4.14±2.14	
WOMAC functional status		30.38±11.80	
VAS		5.52±1.67	

Notes: All values are presented as mean ± SD or n (%)
Abbreviations: BMI: body mass index; VAS: visual analogue scale; WOMAC: Western Ontario and McMaster Index

The VAS score of participants was 5.52±1.67 in the participants. The WOMAC total score of the participants in the research was 42.96±14.60. Table 2 shows the correlations between adjusted dietary protein intakes with pain severity and functional status. There was a negative and significant association between the total adjusted dietary protein and adjusted animal-based protein intake with pain severity. In the analysis of the findings by the gender of participants, there were negative and significant correlations between the total adjusted dietary protein, adjusted plant-based protein, and adjusted animal-based protein intakes with pain severity only in women but not men. We couldn't find any significant correlation between dietary protein intakes with WOMAC total, WOMAC pain, WOMAC stiffness, and WOMAC physical function subscale scores (all p>0/05).

Table 2. The association between adjusted dietary protein intake with VAS and WOMAC scores in participants

Protein intake		Test result	VAS	WOMAC total	WOMAC pain	WOMAC stiffness	WOMAC Functional status
Total protein intake	All patients (n=220)	Coefficient	-0.160	0.016	0.053	0.065	-0.005
		p*	0.016	0.821	0.446	0.352	0.941
	Males (n=68)	Coefficient	-0.065	0.190	0.232	0.158	0.176
		p*	0.605	0.130	0.063	0.318	0.161
	Females (n=152)	Coefficient	-0.394	0.052	0.102	0.087	0.028
		p*	<0.001	0.535	0.223	0.299	0.740
Plant-based protein intake	All patients (n=220)	Coefficient	-0.130	-0.012	0.021	0.037	-0.029
		p*	0.057	0.861	0.765	0.590	0.680
	Males (**n**=68)	Coefficient	-0.073	0.140	0.173	0.242	0.132
		p*	0.559	0.268	0.168	0.052	0.293
	Females (n=152)	Coefficient	-0.350	0.019	0.068	0.050	-0.002
		p*	<0.001	0.819	0.419	0.552	0.977
		Coefficient	-0.149	0.051	0.081	0.082	0.031

Protein intake		Test result	VAS	WOMAC total	WOMAC pain	WOMAC stiffness	WOMAC Functional status
Animal-based protein intake	All patients (n=220)	p*	0.029	0.462	0.241	0.238	0.655
		Coefficient	-0.019	0.154	0.185	0.195	0.139
	Males (**n**=68)	p*	0.880	0.219	0.139	0.119	0.269
		Coefficient	-0.369	0.086	0.127	0.120	0.064
	Females (n=152)	p*	<0.001	0.301	0.127	0.152	0.444

Notes: * Spearmen correlation test
Abbreviations: VAS: visual analogue scale; WOMAC: Western Ontario and McMaster Index

In the subset of participants whose protein intakes were lower than 75 percent of RDA, there were negative and significant correlations between the total adjusted dietary protein and adjusted animal-based protein intakes with pain severity (Table 3). Additionally, there were negative and significant correlations between the adjusted total protein intakes, and adjusted animal-based protein intakes, and WOMAC total score (p=0.006 and p=0.010, respectively), WOMAC pain score (p=0.008, p=0.013, respectively), and WOMAC stiffness score (p=0.003 and p=0.004, respectively). In these patients, there were also negative and significant correlations between total adjusted dietary protein, plant-based protein, and animal-based protein intakes with WOMAC functional scores (p=0.004, p=0.006, and p=0.011, respectively).

Table 3. The association between adjusted dietary protein intake with VAS and WOMAC scores in participants with protein intake of less than 75% RDA

Protein intake	Test result	VAS	WOMAC total	WOMAC pain	WOMAC stiffness	WOMAC Functional status
Total protein intake	Coefficient	-0.320	-0.280	-0.272	-0.305	-0.289
	p*	0.001	0.006	0.008	0.003	0.004
Plant-based protein intake	Coefficient	-0.147	-0.189	-0.187	-0.199	-0.207
	p*	0.145	0.067	0.069	0.053	0.044
Animal-based protein intake	Coefficient	-0.394	-0.265	-0.253	-0.296	-0.261
	p*	<0.001	0.010	0.013	0.004	0.011

Notes: * Spearmen correlation test
Abbreviations: RDA: recommended dietary allowance; VAS: visual analogue scale; WOMAC: Western Ontario and McMaster Index

As shown in Table 4, higher intakes of total and animal-based protein correlated significantly with higher SLM and LBM in women. Furthermore, there was a negative and significant correlation between adjusted plant protein and MBF in women.

Table 4. The association between adjusted dietary protein intakes with body composition indices in participants

Protein intake	Test result		MBF	SLM	LBM
Total protein intake	All patients (n=220)	Coefficient	-0.130	0.145	0.156
		p*	0.223	0.184	0.154
	Males (n=68)	Coefficient	0.045	0.115	0.173
		p*	0.726	0.364	0.124
	Females (n=152)	Coefficient	-0.198	0.257	0.281
		p*	0.043	0.015	0.008
Plant-based protein intake	All patients (n=220)	Coefficient	0.048	0.187	0.196
		p*	0.484	0.094	0.061
	Males (**n**=68)	Coefficient	0.022	0.131	0.129
		p*	0.870	0.304	0.333
	Females (n=152)	Coefficient	-0.235	0.197	0.207
		p*	0.047	0.087	0.069
Animal-based protein intake	All patients (n=220)	Coefficient	0.041	0.164	0.178
		p*	0.550	0.117	0.097
	Males (**n**=68)	Coefficient	-0.050	0.131	0.151
		p*	0.695	0.108	0.081
	Females (n=152)	Coefficient	0.105	0.313	0.329
		p*	0.318	0.007	0.004

Notes: * Spearmen correlation test
Abbreviations: LBM: lean body mass; MBF: mass of body fat; SLM: soft lean mass

Pain severity correlated positively with MBF (p=0.001) and negatively with SLM (p=0.032) and LBM (p=0.014). MBF also correlated positively with WOMAC total and WOMAC pain scores (p=0.039 and p=0.004, respectively). Additionally, lower LBM correlated significantly with higher WOMAC stiffness scores in patients (p=0.047). In the analysis of the findings by the gender of participants, there were significant correlations between MBF and pain severity (p<0.001) in men and also between MBF and pain severity (p<0.001), WOMAC total score (p=0.011) and WOMAC pain score (p<0.001) in women. In women, higher SLM and LBM correlated significantly with lower WOMAC total (p=0.013 and p=0.006, respectively) and WOMAC pain scores (p=0.028 and p=0.004, respectively). Furthermore, LBM correlated with WOMAC stiffness (p=0.003) and WOMAC physical function (p=0.024) scores negatively in women but not in men. Data are shown in Table 5.

Table 5. The association between the body composition with VAS and WOMAC scores in participants

Body composition			VAS	WOMAC total	WOMAC pain	WOMAC stiffness	WOMAC Physical function
MBF	All patients (n=220)	Coefficient	0.476	0.168	0.195	0.086	0.102
		p*	0.001	0.039	0.004	0.519	0.169
	Males (**n**=68)	Coefficient	0.452	0.020	0.064	0.094	-0.015
		p*	<0.001	0.874	0.618	0.642	0.907
	Females (n=152)	Coefficient	0.745	0.221	0.306	0.049	0.122
		p*	<0.001	0.011	<0.001	0.369	0.085
SLM	All patients (n=220)	Coefficient	-0.176	-0.007	0.019	0.040	-0.029
		p*	0.032	0.923	0.788	0.559	0.675
	Males (**n**=68)	Coefficient	-0.185	-0.079	-0.128	-0.166	-0.032
		p*	0.209	0.537	0.317	0.192	0.804
	Females (n=152)	Coefficient	-0.273	-0.202	-0.191	-0.092	-0.079
		p*	<0.001	0.013	0.028	0.108	0.326
LBM	All patients (n=220)	Coefficient	-0.163	-0.049	-0.073	-0.097	0.117
		p*	0.014	0.407	0.217	0.047	0.090
	Males (**n**=68)	Coefficient	-0.172	-0.189	-0.156	-0.159	-0.135
		p*	0.174	0.091	0.127	0.115	0.355
			-0.208	-0.228	-0.234	-0.246	-0.185

Body composition		VAS	WOMAC total	WOMAC pain	WOMAC stiffness	WOMAC Physical function
Females (n=152)	Coefficient					
	p*	0.011	0.006	0.004	0.003	0.024

Notes:* Spearmen correlation test
Abbreviations: LBM: lean body mass; MBF: mass of body fat; SLM: soft lean mass; VAS: visual analogue scale; WOMAC: Western Ontario and McMaster Index

Discussion

In this study, we investigated 220 patients with knee OA to evaluate the possible relationship between dietary protein intake and body composition analysis, pain, and functional status. Total protein intake was 55.36±24.14 grams (0.70±0.31 grams per kg weight) per day. According to the results of this study, 70 percent of participants did not meet the protein RDA of whom more than forty percent consumed lower than three-fourths of RDA.

The recommended dietary intake for adults based on the diet and nutrition board is 0.8 g per kilogram of body weight per day. Receiving protein equivalent to 17-21% of the daily calorie in adults of all ages is required **(20)**. In the elderly, to maintain muscle function, more amounts of 1-1.2 g protein per kilogram of body weight per day and even 1-2.5 g protein per kilogram of body weight per day are suggested, partly because of anabolic resistance that is disturbed by repercussions in the synthesis of protein in muscles on dietary protein intake **(15)**. It is particularly vital in the elderly with malnutrition or at risk of malnutrition due to acute or chronic illness or injury.

According to the previous studies focused on much younger participants, the popular features of Iranian dietary intake comprise a high consumption of refined grains and hydrogenated fats and also a high energy intake from carbohydrates which are comparable to those of the dietary patterns in the Middle East, Europe, and the United States **(21)**. A small number of investigations have been performed for energy and macronutrient intake evaluation among middle-aged and elderlies, in Iran and worldwide. Along with the results of the present study, Zwart *et al.* **(15)** found that the current RDA for protein intake is met by only 34.9% of the patients with knee osteoarthritis. According to the National Health and Nutrition Examination Survey, 7–41 percent of older adults were described to have a daily protein intake lower than the RDA. Additionally, this survey has shown that protein intake is reduced with age. So, at the age of 19-30, it is 91 ± 22 g /day and decreases in the elderly by about 66 ± 17 g / day **(20)**. In the study by Heidari *et al.*, the mean for daily protein consumption in men (86 and 70 g) was lesser than those reported in a study in United States (approximately 102 g) **(22)**. Animal-based protein Per capita consumption among Iranian people is significantly lower than among American or European populations (9.2 kg per capita compared with 65.3 and 58.3 kg per capita, respectively) **(23)**. In the study by Farvid *et al.*, the mean consumption of total red meat was only 0.19 servings per day in the Golestan Cohort Study in Iran **(24)**. These suggest that daily dietary protein intake requires to be improved and that dietary protein consumption could be a practical intervention objective, especially in elderly patients with a chronic disease (knee OA).

According to our findings, the dietary protein intake was higher in men than in women. However, the dietary animal based/plant-based protein ratio was significantly higher in women than in men. Consistent with our findings, other surveys described higher macronutrient intakes in men than in women **(25)**.

According to findings, patients who consumed higher total and animal-based proteins had lower pain severity. The reverse correlation between plant-based protein intake and pain severity was found only in women.

In patients with protein intakes lower than 75 percent of RDA, higher physical dysfunction, according to WOMAC total, WOMAC pain, and WOMAC stiffness scores, correlated with lower intakes of total and animal-based protein. There was also a reverse correlation between all types of protein intakes with physical dysfunction, according to WOMAC functional score, in these patients.

Dietary protein intake has a vital role in relieving pain through muscle recuperation. The protein supplements decrease muscle injury and benefit muscle recovery by renovating skeletal muscle. Published articles are scarce on the correlation between dietary protein intake and pain severity in OA. Noh *et al.* **(26)** showed that inadequate protein intake (<0.8 g/kg/day) correlated with high odds of pain in women with low back pain (LBP) (OR 1.83; 95% CI 1.12–2.99). Shell *et al.* **(27)** studied the effects of The raminem, an amino acid blend 68405-1, on joint pain. Park **(28)** showed that adults over 40 with high polygenic risk scores (PRS) should have a higher protein intake to alleviate OA risk.

According to the findings, women with higher total and animal protein intakes had higher SLM and LBM.

Furthermore, women with higher plant-based protein intake had lower MBF.

The influence of protein consumption on muscle mass is of specific concern in knee OA due to the medical importance of muscle strength in this disorder **(14)**. Generally, most animal-based protein sources are considered high quality for supporting essential amino acid necessities for human growth and development **(11)**. Plant-based proteins may have inadequate amounts of one or more essential amino acids. Legumes are low in the sulfur-containing amino acids methionine and cysteine, and lysine is limiting in grains. However, plant-based proteins correlated with benefits concerning health and physical function **(29)**. In previous studies, a protein diet was associated with muscle mass. In a community-level investigation of adults, participants in the highest quartile protein intake lost 40% less lean mass comparing the lowest quartiles over the three years. Receiving 1.1 g protein per kilogram of body weight per day or 18% of dietary calories was found to be associated with the lowest loss of LBM in the elderly (70-79 years old) **(30)**.

Proteins are macronutrients and have crucial role in many physiological procedures involved in body homeostasis, comprising the structure and function. While carbohydrates and fat are stored in the body for use in conditions of necessity, protein cannot be stored in an inactive compound, so an acceptable source of dietary proteins is vital to preserving body homeostasis and function **(7)**. Low protein intake through diet (less than 0.45 g per kilogram body weight per day) in the elderly is associated with decreased plasma levels of IGF-I and fibroblastic atrophy of skeletal muscle **(8)**.

According to our findings, patients with higher MBF and lower SLM and LBM had higher pain severity based on VAS. Additionally, higher MBF and lower LBM correlated with higher physical disabilities according to WOMAC total and pain scores and WOMAC stiffness scores, respectively. In women, lower SLM was associated with higher WOMAC total and pain scores. LBM was also reversely correlated with WOMAC stiffness and physical function scores in women but not men.

Jeanmaire C *et al.* **(31)** examined an association between low LBM with OA symptoms (pain, dysfunction, and quality of life) in 358 patients with a cross-sectional pattern. Low LBM significantly correlated to the quality of life and WOMAC score disorder. In patients with normal BMI, WOMAC scores in patients with lower lean body mass were higher than those with the normal body composition analysis findings, and the components of quality of life score were lower.

Along with our study, Zoico *et al.* **(32)** reported that a high total body fat mass independent of lean mass is associated with limiting climbing stairs in women. Based on the evidence, gender is an important determinant, and women are more affected than men **(33)**. In a cohort study **(34)** that evaluated foot pain in an overweight population, an increase in fat mass, rather than a weight loss, was predictive of foot pain.

Leptin is a pro-inflammatory adipokine. Leptin is dominantly secreted by subcutaneous fat tissue and is a mediator of weight loss and knee OA. The association between leptin with malignant skeletal muscle pain has been shown in women **(35)**. The articular chondrocytes have a receptor for leptin, so a mechanical pathway provides a direct route to the adipose tissue to interfere with articular cartilage, which justifies the relationship between obesity and knee pain with topical function.

According to the findings, daily dietary protein intake needs to improve in patients with knee OA. The dietary protein intake might be an intermediation objective in patients with knee OA. However, enhancing muscle protein synthesis through dietary protein intake is more complicated than improving the daily protein intake. Focusing on daily dietary protein intake does not equal higher dietary calorie consumption, because the prevalence of overweight/obesity is considerable in patients with knee OA and weight control is highly recommended.

The study has some limitations. Firstly, it is impossible to make any causal conclusion about the relationship between dietary protein intake and body composition analysis in the cross-sectional data. Secondly, the dietary protein intake was evaluated using the semi-quantitative FFQ. Retrospective food frequency questionnaires are less precise in measuring food intake than the nutrition diary. Thirdly, although the association between dietary protein intake and body composition is biologically acceptable, the probability that total energy intake can be (partly) accountable for this correlation cannot be excluded.

Conclusion

The results of this study propose that most participants with knee OA had a dietary protein intake lower than the current RDA. Patients with higher dietary total and animal-based protein intakes had lower pain severity. In patients with protein intakes lower than 75 percent of RDA, higher dietary total and animal-based protein correlated with lower physical disabilities. In women with knee OA, higher total and animal-based protein intakes were associated with a higher SLM and LBM and higher plant-based protein intake were associated with a lower MBF. MBF correlated positively, and SLM and LBM correlated negatively with pain severity in the patients. The patients with higher MBF and lower LBM had higher physical dysfunction according to the various subscales of the WOMAC index. This study opens new horizons in the nutritional care of subjects with knee OA. More studies with the longitudinal and interventional design are required to prove whether dietary protein intake has a causal impact on body composition, pain, and functional disorder in subjects with knee OA.

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Conflict of Interest

All authors declare they have no conflict of interest.

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