

THE RELATIONSHIP BETWEEN SEEDS CONSUMPTION, LIPID PROFILE AND BODY MASS INDEX AMONG PATIENTS WITH CARDIOVASCULAR DISEASES

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ABSTRACT

Background. Cardiovascular disease (CVD) is the leading cause of death worldwide and largely preventable through improving diet quality and other lifestyle factors. In recent years, dietary recommendations have shifted towards diets high in plant-based foods and low in animal-based foods for the prevention of chronic diseases.

Objective. This study aims to evaluate the relationship between seeds consumption, lipid profile and body mass index (BMI) in a group of 889 (313 female and 576 male) randomly selected patients hospitalized in the Nitra Cardio Center, Slovakia.

Material and Methods. The data necessary for the evaluation the relationship between seeds consumption, lipid profiles and BMI were obtained by a questionnaire method in closed-ended format. Data collection was carried out simultaneously with the anthropometric and biochemical examinations of the respondents ensured by the Nitra Cardio Center. The following parameters were assessed in the blood: total cholesterol (T-C), low-density cholesterol (LDL-C), high-density cholesterol (HDL-C), triglycerides (TG), and glucose (GLU). Comparisons between groups were made utilizing one-way analysis of variance (ANOVA) followed by *Tukey's post hoc* test.

Results. Respondents indicated pumpkin seeds as the most commonly consumed seeds (45.19% of women and 53.06% of men) and their preference did not cause changes in lipid profile. Women who consume seeds 1-2 times/month had significantly lower levels of T-C and LDL-C compared to women non-consuming seeds ($P < 0.05$). In men, we did not observed any changes in lipid profile. The lowest BMI in women was associated with flaxseed preference and in men with sunflower preference. Increasing frequency of seeds consumption of women and men did not cause changes in BMI.

Conclusions. Based on beneficial effects of seeds on cardiovascular risk factors, it seems that seeds consumption can be considered as a useful therapeutic approach for reducing lipid profile and body mass index.

Key words: cardiovascular disease, lipid profile, seeds, flaxseed, pumpkin, sunflower, sesame, body mass index

STRESZCZENIE

Wprowadzenie. Choroby ukłdu krżenia (CVD) s głwn przyczyn zgonw na całm świcie i mořna im w duřej mierze zapobiec poprzez poprawę jakości diety i innych czynnikw zwizanych ze stylem Źycia. W ostatnich latach zalecenia Źywieniowe przesunęły się w kierunku diety bogatej w Źywność pochodzenia roślinnego i ubogiej w Źywność pochodzenia zwierzęcego w celu zapobiegania chorobom przewlekłm.

Cel. Niniejsze badanie ma na celu ocenę zwizku międy spořyciem nasion, profilem lipidowym i BMI w grupie 889 (313 kobiet i 576 męzczyzn) losowo wybranych pacjentw hospitalizowanych w Nitra Cardio Center na Słowacji.

Material i metody. Dane niezbędne do oceny zaleřności międy spořyciem nasion, profilami lipidowymi i BMI uzyskano metod ankietow stosujc pytania zamknięte. Zbieranie danych odbywało się równolegle z badaniami antropometrycznymi i biochemicznymi respondentw zapewnianymi przez Centrum Nitra Cardio. Oceniano we krwi stężeńia następujących parametrw: cholesterol całkowity (T-C), cholesterol o niskiej gęstości (LDL-C), cholesterol o duřej gęstości (HDL-C), trjglicerydy (TG) i glukozę (GLU) we krwi. Porwnania międy grupami dokonano wykorzystujc jednokierunkow analizę wariancji (ANOVA), a następnie test *post hoc Tukeya*.

Wyniki. Respondenci wskazali pestki dyni jako najczęściej spořywane nasiona (45,19% kobiet i 53,06% męzczyzn), a ich preferencje nie powodowały zmian w profilu lipidowym. Kobiety, które spořywały nasiona 1-2 razy w miesicu, miały statystycznie znacznie niřszy poziom T-C i LDL-C w porwnaniu z kobietami nie spořywajcymi nasion ($P < 0,05$). U męzczyzn nie zaobserwowaliśmy Źadnych zmian w profilu lipidowym. Najniřsze BMI u kobiet wizało się

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z preferowaniem nasion lnu, a u mężczyzn z preferencją słonecznika. Rosnąca częstotliwość spożycia nasion przez kobiety i mężczyzn nie powodowała zmian wskaźnika BMI.

Wnioski. Opierając się na korzystnym wpływie nasion na czynniki ryzyka chorób układu sercowo-naczyniowego, wydaje się, że spożycie nasion można uznać za przydatne podejście terapeutyczne do obniżania profilu lipidowego i wskaźnika masy ciała.

Słowa kluczowe: choroby układu krążenia, profil lipidowy, nasiona, siemię lniane, dynia, słonecznik, sezam, wskaźnik masy ciała

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death worldwide and largely preventable through improving diet quality and other lifestyle factors [36, 50, 55]. Multiple cardiovascular risk factors, including hyperlipidemia, hypertension, diabetes and smoking are associated with excessive production of reactive oxygen species and increased oxidative stress and inflammation, and promote vascular cell damage. Consequently, increased inflammation and oxidative stress is considered the major mechanism of the pathogenesis of endothelial dysfunction [4, 23]. Diet can affect CVD directly by modulating the composition of vascular plaques, and indirectly by affecting the rate of aging [36].

In recent years, dietary recommendations have shifted towards diets high in plant-based foods and low in animal-based foods for the prevention of chronic diseases [25, 27, 37, 47]. This dietary pattern has been associated with lower risk of CVD [11, 16, 20, 28] and is widely recommended for heart health [32].

Most of these plant-based dietary patterns highlight the intake of nuts as a key component [49, 55]. The integral role of seeds in pre-agricultural diets is understandable given their high energy and nutrient density [52]. In general, they are dense in a variety of nutrients and provide protein, fat (mostly unsaturated fatty acids), dietary fiber and many bioactive constituents such as vitamins (e.g. folic acid, niacin, vitamin E, vitamin B₆), minerals (e.g. copper, magnesium, potassium, zinc), antioxidants, phytoestrogens and other phytochemicals [19, 50, 51, 54, 55].

Nuts and edible seeds are recognized for their nutritional value and potential contribution to health promotion [38, 48]. Nuts and seeds may be considered an important component of a healthy diet and are regularly consumed, either as snacks or part of a meal [19]. In the last decade a large body of scientific evidence has been built on the beneficial effects of increasing consumption of plant seeds and derived products on various health outcomes, chiefly CVD, type 2 diabetes mellitus (T2DM) and intermediate markers [51, 52]. There is substantial evidence that increased consumption of seeds is associated with lower risk of CVD and T2DM or a significant

reduction in CVD risk factors such as serum cholesterol or blood pressure [51]. In addition, nuts and edible seeds provide antioxidant, anti-microbial, anti-inflammatory, anti-mutagenic, anti-cancer, anti-diabetic and glucoregulatory properties [30, 41].

Functional foods with positive effects on health are good choices for reducing the risk of chronic diseases [8, 43]. Flaxseed is the richest source of plant α -linolenic acid (ALA) and lignans [44]. Due to its high content of lignans, fiber, phytosterols and ALA, flaxseed was recently recognized as a functional food that may reduce cardiovascular disease risk factors such as hypertension and hyperlipidemia [8, 13, 14, 17, 29, 46, 62]. Results from studies have reported that some bioactive compounds found in the pumpkin seed oils are mainly polyphenols (phenolic acids, flavonoids, anthocyanins, lignans, and stilbenes), carotenoids (xanthophylls and carotenes) and vitamins (vitamin E and C) act as a natural anti-oxidant [3, 7, 12]. The pumpkin seed oil has also demonstrated various other beneficial properties like anti-microbial, anti-hypertensive, anti-arthritic, anti-inflammatory, and anti-depression activities [2, 33, 61, 63] and pumpkin seed oil is also well recognized for the treatment of urinary tract infection and other infectious diseases [39]. Sunflower is an excellent source of phenolics and showed the highest antioxidant capacity even though its lignan content is limited. Sesame provide a good source of phenolics, but their peculiar contribution is in term of lignans [21, 60]. This study aims to evaluate the relationship between seeds consumption, lipid profile and body mass index in a group of randomly selected patients hospitalized in the Nitra Cardio Center, Slovakia.

MATERIALS AND METHODS

Study design and participants

The study was conducted using the direct PAPI (*Paper And Pen Personal Interview*) method. A total of 1255 subjects (455 female and 800 male) were recruited, of which 366 were eliminated because they did not answer all of the questions in the questionnaire. Finally, 889 participants (313 females and 576 males) aged 20-101 years were included for further analysis, translating to a response rate of 70.84%. The average age of women was 64.30 ± 10.03 years and the average age of men was 60.79 ± 9.94 years. Respondents

included in the study had either overcome myocardial infarction or were diagnosed with angina pectoris and hospitalized after undergoing catheterization. Data were collected during the years 2015–2020.

Ethical aspects

The research was conducted according to the guidelines of the Declaration of Helsinki and approved by Nitra Cardio Center and by the Ethics Committee at the Specialized Hospital St. Zoerardus Zobor, n. o. Nitra, Slovak Republic (protocol number 10.6.2014).

Dietary data

The data necessary for the evaluation the relationship between seeds consumption, lipid profiles and BMI were obtained by a questionnaire method in closed-ended format. The questionnaire was compiled by the Department of Human Nutrition (Slovak University of Agriculture in Nitra) and approved by the Nitra Cardio Center. The questionnaire was applied individually by a single interviewer. The questionnaire contained two parts. The first part included questions concerning the socio-demographic situation of the subjects, physical activity, use of tobacco, and medical history. The second part of the questionnaire concerned the analysis of selected dietary habits, including the number of the consumed meals, their regularity, snacking between meals, types of snacks consumed, and the eating frequency of selected groups of food products. In the dietary questionnaires, we asked participants how often they had consumed a seeds during the preceding year: never, 1-2 times/month or 1-2 times/week. The questionnaire was anonymous; its completion was voluntary, with only one response to be circled for each question.

Biochemical parameters

Data collection was carried out simultaneously with the somatometric and biochemical examinations of the respondents ensured by the Nitra Cardio Center. All biochemical parameters were measured in certified

hospital laboratory using the Automatic Biochemical Analyzer BioMajesty® JCA-BM6010/C (DiaSys Diagnostic System GmbH, Holzheim, Germany). The following parameters were evaluated: total cholesterol (T-C), low-density cholesterol (LDL-C), high-density cholesterol (HDL-C), triglycerides (TG), and glucose (GLU).

Anthropometric parameters

Anthropometric measurements were performed in the morning with a standard manner (on an empty stomach, after urination and defecation). Anthropometric parameters - body weight (kg) and height (cm) were measured on outpatient electronic medical scales (Tanita WB-3000, Tanita Co., Tokyo, Japan). The body mass index (BMI) was calculated by dividing the body weight in kilograms by the square of the height in meters.

Statistical analysis

Statistical analysis was carried out using the Statistica version 10 and MS Excel 2007 (Microsoft Corporation, Redmond, Washington, USA). Data were expressed in figures and tables as average \pm standard deviation (SD). We also presented minimum and maximum, categorical variables are reported as percent values. Comparisons between groups were made utilizing one-way analysis of variance (ANOVA) followed by *Tukey's post hoc* test. The Chi-square test was used for categorical variables. The statistical significance was established at $P < 0.05$.

RESULTS AND DISCUSSION

Characteristics of study participants

From the obtained individual values, we calculated the basic statistical characteristics (Table 1).

Of the 889 participants, 481 (54.10%) were retiree, 559 (62.88%) were married and 331 (37.23%) participants had attained a graduation. The demographic characteristics of study participants is shown in Table 2.

Table 1. Basic characteristics of study participants

n=889 Parameters	Women (n=313)		Men (n=576)	
	average \pm SD	min. – max.	average \pm SD	min. – max.
Age (yrs)	64.30 \pm 10.03	35 – 90	60.79 \pm 9.94	20 – 101
BMI (kg.m ⁻²)	29.31 \pm 4.02	19.00 – 43.11	29.70 \pm 4.51	17.90 – 52.01
T-C (mmol.L ⁻¹)	4.83 \pm 1.24	1.95 – 8.69	4.62 \pm 1.17	1.99 – 9.18
LDL-C (mmol.L ⁻¹)	2.79 \pm 1.04	0.69 – 5.89	2.88 \pm 0.98	0.61 – 7.19
HDL-C (mmol.L ⁻¹)	1.47 \pm 0.51	0.57 – 4.55	1.16 \pm 0.39	0.45 – 4.01
TG (mmol.L ⁻¹)	1.62 \pm 1.14	0.35 – 8.27	1.74 \pm 0.93	0.43 – 7.39
GLU (mmol.L ⁻¹)	6.92 \pm 3.49	2.23 – 27.07	6.67 \pm 2.31	3.98 – 24.12

Data are expressed as average \pm standard deviation (SD), min. – max.; BMI, body mass index; T-C, total cholesterol; LDL-C, low density cholesterol; HDL-C, high density cholesterol; TG, triglycerides; GLU, glucose

Table 2. Demographic characteristics of study participants

Parameters	Women (n=313) n (%)	Men (n=576) n (%)	All participants (n=889) n (%)
<i>Social status</i>			
employed	78 (24.92)	207 (35.94)	285 (32.06)
unemployed	25 (7.99)	98 (17.01)	123 (13.84)
retiree	210 (67.09)	271 (47.05)	481 (54.10)
<i>Family status</i>			
married	158 (50.48)	401 (69.62)	559 (62.88)
divorced	52 (16.61)	92 (15.97)	144 (16.20)
widower	103 (32.91)	83 (14.41)	186 (20.92)
<i>Education</i>			
basic	66 (21.09)	67 (11.63)	133 (14.96)
apprenticeship	77 (24.60)	176 (30.56)	253 (28.46)
graduation	130 (41.53)	201 (34.90)	331 (37.23)
higher	40 (12.78)	132 (22.92)	172 (19.35)

Basic characteristics of participants based on frequency of seeds consumption

The results revealed significant differences ($P < 0.001$) of basic characteristics among three different seeds consumption categories (Table 3). Consumption of seeds (1-2 times/week) was most common among

younger women, lower BMI, fewer smokers, more physically active, those with positive family history of dyslipidemia, lower alcohol drinking, more consumption of red meat, fruits, vegetables and lower consumption of whole dairy products. We observed different results in men, seed consumption (1-2

Table 3. Basic characteristics of participants based on frequency of seeds consumption

Characteristics	Frequency of consumption seeds			P
	1-2 times/week	1-2 times/month	never	
Women (n=313)				
Age (years)	63.43 ± 7.68	64.75 ± 8.92	63.50 ± 10.97	-
BMI (kg.m ²)	28.31 ± 3.52	29.49 ± 4.3	29.74 ± 4.52	-
Current Smoking (%)	16.00	17.54	16.13	P < 0.001
Physical activity <30 min/day (%)	18.67	30.70	28.23	P < 0.001
Family history of dyslipidemia (%)	45.33	28.95	29.84	P < 0.001
Alcohol >5 drinks/week (%)	10.67	14.03	14.52	P < 0.001
Red meat >3 times/week (%)	9.33	8.77	8.87	P < 0.05
Fruits - no daily (%)	4.0	7.02	18.55	P < 0.001
Vegetables - no daily (%)	13.33	24.56	30.65	P < 0.001
Whole dairy product (%)	49.33	61.40	57.26	P < 0.001
Men (n=576)				
Age (years)	61.55 ± 9.69	59.09 ± 9.12	61.84 ± 9.60	-
BMI (kg.m ²)	29.57 ± 3.55	29.60 ± 4.51	29.67 ± 5.28	-
Current Smoking (%)	12.62	23.96	26.17	P < 0.001
Physical activity <30 min/day (%)	22.33	14.75	21.88	P < 0.001
Family history of dyslipidemia (%)	30.10	33.64	44.53	P < 0.001
Alcohol >5 drinks/week (%)	7.76	9.68	16.40	P < 0.001
Red meat >3 times/week (%)	8.74	5.99	11.71	P < 0.001
Fruits - no daily (%)	18.45	18.89	25.39	P < 0.001
Vegetables - no daily (%)	20.39	24.42	30.86	P < 0.001
Whole dairy product (%)	69.97	62.67	63.28	P < 0.001

times/week) was most common in older men, higher BMI, fewer smokers, less physically active, lower positive family history of dyslipidemia, lower alcohol consumption, higher consumption of fruits, vegetables and whole dairy products.

Effect of the species and frequency of consumption of seeds on lipid profile

Respondents indicated pumpkin seeds as the most commonly consumed seeds (45.19% of women and 53.06% of men). The second most frequently consumed was sunflower seed which consume 16.74% of women and 25.55% of men ($P < 0.001$) (Figure 1).

Thus, recent studies on pumpkin seed oil indicate that they have gained much attention not only as an edible oil but also as a potential nutraceutical [3, 7,

12, 35]. Pumpkin seed is being used traditionally for curing and protecting various ailments [4].

The preference of pumpkin seeds in women and men did not cause changes in lipid profile. The mean serum lipids of participants based on species of seeds consumption is shown in Table 4. Some human clinical trials found that consumption of 30-50 g of flaxseed per day for four to 12 weeks resulted in an 8-14% decrease in LDL-C levels [5, 15, 42, 56], while other trials did not observe significant reductions in LDL-C after adding 30-40 g flaxseed per day to the diet [31, 34, 57]. Daily consumption of flaxseed (40 g) decreased LDL-C, T-C and TG lipoprotein and increased HDL-C concentrations in healthy menopausal women after 12 months [18]. Significant reductions in T-C, LDL-C and TG levels were seen

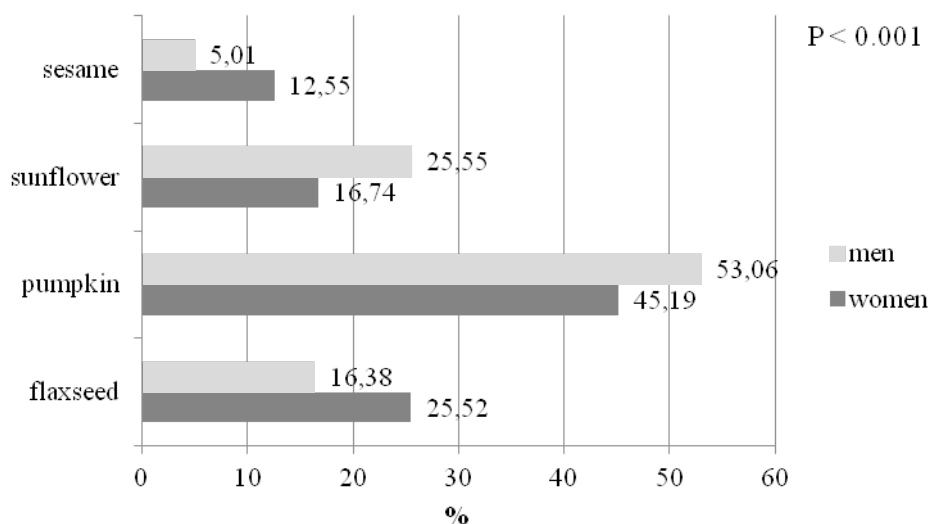


Figure 1. The most frequently consumed seeds (n=889)

Table 4. The mean serum lipids of participants based on species of seeds consumption

Species	n (%)	Lipid profile (mmol.L ⁻¹)			
		T-C	HDL-C	LDL-C	TG
Women (n=313)					
flaxseed	79 (25.52)	4.71 ± 1.28	1.49 ± 0.35	2.71 ± 1.08	1.48 ± 1.39
pumpkin	142 (45.19)	4.77 ± 1.11	1.49 ± 0.59	2.70 ± 0.94	1.68 ± 1.04
sunflower	53 (16.74)	4.73 ± 1.20	1.40 ± 0.41	2.81 ± 1.01	1.54 ± 0.69
sesame	39 (12.55)	4.19 ± 1.00	1.37 ± 0.45	2.53 ± 0.94	1.58 ± 0.74
P	-	P > 0.05	P > 0.05	P > 0.05	P > 0.05
Men (n=576)					
flaxseed	94 (16.38)	4.70 ± 1.21	1.09 ± 0.24	2.99 ± 0.94	1.83 ± 0.96
pumpkin	306 (53.06)	4.69 ± 1.28	1.13 ± 0.45	2.95 ± 1.02	1.80 ± 1.00
sunflower	147 (25.55)	4.60 ± 1.18	1.15 ± 0.30	2.91 ± 1.04	1.57 ± 0.70
sesame	29 (5.1)	4.92 ± 1.34	1.17 ± 0.45	3.27 ± 1.16	1.55 ± 0.80
P	-	P > 0.05	P > 0.05	P > 0.05	P > 0.05

Data are expressed as average ± standard deviation (SD); *Tukey's post hoc* test; T-C, total cholesterol; HDL-C, high density cholesterol; LDL-C, low density cholesterol; TG, triglycerides

within each group after treatment with flaxseed oil and sunflower oil [1]. Flaxseed supplementation was well-tolerated and resulted in a consistent and significant decrease in T-C and LDL-C levels [29].

We also monitored the mean serum lipids of participants based on frequency of seeds consumption (Table 5). Women who consume seeds 1-2 times/month had significantly lower levels of T-C and LDL-C compared to women non-consuming seeds ($P < 0.05$). In men, we did not observe any changes in lipid profile.

Effect of the seeds consumption on body mass index

Nuts and seeds are energy dense foods that have been thought to be positively associated with increased body mass index. Despite the relatively high energy density, intake of nuts was actually

associated with less weight gain, lower risk of obesity, and lower risk of moderate weight gain in prospective studies [6, 9, 10]. Some of the reported health benefits derived from nut and seed consumption are control of body weight and blood pressure, reduction of coronary heart disease, and reduction of levels of blood cholesterol and triacylglycerols [30, 45]. Our results show that the different preference and frequency of seeds consumption did not cause changes in BMI. The mean BMI of participants based on species and frequency of seeds consumption is shown in Table 6. *Haghighatsiaret et al.* [26] demonstrated that incorporating whole flaxseed into the diet of hyperlipidemic and hypertensive patients along with healthy dietary recommendations for 8 weeks could reduce anthropometric measurements - waist circumference (WC) and waist to hip ratio

Table 5. The mean serum lipids of participants based on frequency of seeds consumption

Frequency	Parameter (mmol.L ⁻¹)				
	n (%)	T-C	HDL-C	LDL-C	TG
Women (n=313)					
1-2 times/week	75 (24.03)	4.67 ± 1.06	1.49 ± 0.31	2.84 ± 0.95	1.39 ± 0.58
1-2 times/month	114 (36.44)	4.77 ± 1.08 ^a	1.49 ± 0.64	2.52 ± 0.93 ^a	1.71 ± 1.10
never	124 (39.53)	5.05 ± 1.30 ^b	1.48 ± 0.49	2.94 ± 1.06 ^b	1.82 ± 1.51
P	-	$P < 0.05$	$P > 0.05$	$P < 0.05$	$P > 0.05$
Men (n=576)					
1-2 times/week	103 (17.89)	4.58 ± 1.17	1.14 ± 0.50	2.85 ± 0.94	1.72 ± 0.95
1-2 times/month	217 (37.60)	4.61 ± 1.26	1.15 ± 0.37	2.88 ± 0.99	1.74 ± 0.83
never	256 (44.51)	4.60 ± 1.03	1.20 ± 0.37	2.81 ± 0.90	1.75 ± 0.84
P	-	$P > 0.05$	$P > 0.05$	$P > 0.05$	$P > 0.05$

Data are expressed as average ± standard deviation (SD); *Tukey's post hoc* test, different superscript letters in the same column are significantly different; T-C, total cholesterol; HDL-C, high density cholesterol; LDL-C, low density cholesterol; TG, triglycerides

Table 6. The mean BMI of participants based on species and frequency of seeds consumption

Parameter	Women (n=313)		Men (n=576)	
	n (%)	BMI (kg.m ⁻²)	n (%)	BMI (kg.m ⁻²)
Species				
flaxseed	79 (25.52)	28.43 ± 3.42	94 (16.38)	30.04 ± 5.10
pumpkin	142 (45.19)	29.37 ± 3.92	306 (53.06)	29.74 ± 4.14
sunflower	53 (16.74)	28.89 ± 3.64	147 (25.55)	29.53 ± 3.58
sesame	39 (12.55)	29.95 ± 4.07	29 (5.1)	30.31 ± 5.89
P	-	$P > 0.05$	-	$P > 0.05$
Frequency				
1-2 times/week	75 (24.03)	28.31 ± 3.52	103 (17.89)	29.57 ± 3.55
1-2 times/month	114 (36.44)	29.49 ± 4.3	217 (37.60)	29.60 ± 4.51
never	124 (39.53)	29.74 ± 4.52	256 (44.51)	29.67 ± 5.28
P	-	$P > 0.05$	-	$P > 0.05$

Data are expressed as average ± standard deviation (SD); *Tukey's post hoc* test; BMI, body mass index

(WHR) and improve lipid profiles (TG, T-C, and LDL-C) of participants. In the study of *O'Neil et al* [40] nut consumption was significantly associated with beneficial effects in body mass index, waist circumference, blood pressure, insulin resistance, lower chance of obesity and overweight and increase in HDL-C levels. It is worth mentioning that, in general, an increase in body mass has not been observed with an increased consumption of tree nuts and legume seeds [22, 59]. However, considerable evidence from both epidemiological studies and clinical trials suggests that nuts are not associated with weight gain and may, in fact, help to lose weight when incorporated to an energy restricted diet [58].

CONCLUSION

In our study, we observed the associations between consumption of seeds, lipid profile and BMI in a group of randomly selected patients with CVD. Respondents indicated pumpkin seeds as the most commonly consumed seeds and their preference in women and men did not cause changes in lipid profile. Women who consume seeds 1-2 times/month had significantly lower levels of T-C and LDL-C compared to women non-consuming seeds. The lowest BMI in women was associated with flaxseed preference and in men with sunflower preference. Increasing frequency of seeds consumption of women and men did not cause changes of BMI.

Based on beneficial effects of seeds on cardiovascular risk factors, it seems that seeds consumption can be considered as a useful therapeutic approach for reducing lipid profile and body mass index.

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Conflict of interest

The authors declare no conflict of interest.

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