Dietary phytochemical index and subsequent changes of lipid profile: A 3-year follow-up in Tehran Lipid and Glucose Study in Iran

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Original Article

Abstract

BACKGROUND: High intakes of phytochemical-rich foods have beneficial effects on lipid profiles and cardiovascular disease (CVD). In this study, we assessed the association between the dietary phytochemical index (PI) and changes in lipid profile after 3-year follow-up among Iranian adults.

METHODS: This longitudinal study was conducted in 1983 subjects, aged 19-70 years, selected among participants of the Tehran Lipid and Glucose Study in Iran. Dietary data were collected by using a validated semi-quantitative food frequency questionnaire with 168 food items at baseline. PI was calculated based on daily energy derived from [(phytochemical-rich foods kcal/total daily energy intake kcal) × 100]. Lipid profile was measured at baseline and after 3 years and changes in serum lipid profiles were assessed during 3-year follow-up.

RESULTS: The mean age of participants was 40.4 ± 13.0 years; participants in the highest PI quartile category were more likely to be older. After 3 years of follow-up, total cholesterol was significantly lower in the highest quartile compared with lower quartile of PI in men (181 ± 3 vs. 189 ± 3, _P_ for trend < 0.05). There were significant inverse association between dietary PI and 3 years changes of total cholesterol [β = −5.6, 95% confidence interval (CI) = −9.3, −1.8], triglycerides (β = −13.7, 95% CI = −24.6, −2.8), and non-high-density lipoprotein cholesterol (HDL-C) (β = −6.2, 95% CI = −10.8, −1.5), in highest quartile of PI in men. Lipid profiles showed no significant changes over the study period in women.

CONCLUSION: Higher dietary PI is associated with 3 years improvement of total cholesterol, triglycerides, and non-HDL-C. Higher consumption of phytochemical-rich foods is recommended to prevent CVD.

Keywords: Phytochemical, Triglyceride, Cholesterol, Fruit and vegetables, Whole Grains

Introduction

Cardiovascular disease (CVD) is one of the major public health problems that lead to disability and mortality.[1] Hypercholesterolemia has been investigated as a major risk factor for CVD.[2] Worldwide prevalence of hypercholesterolemia was estimated 39% (37% in men and 40% in women) in 2008; it was associated to 2.6 million deaths and 29.7 million disability-adjusted life years.[1] In Iran, prevalence of hypercholesterolemia was reported 51.7% (48.8% in men and 54.7% in women) in 2008.[3] Prospective studies, have also shown that increased triglycerides and decreased high-density lipoprotein cholesterol (HDL-C) levels are associated with CVD independent of traditional risk factors, suggesting that improvement of these abnormalities as secondary therapeutic targets have protective effects.[4,5] Moreover, non-HDL-C that comprises all atherogenic apolipoprotein B (Apo B) is a better measure for evaluation atherogenic particles and prediction of cardiovascular events than low-density lipoprotein cholesterol (LDL-C).[6]

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It has been demonstrated that dietary modification is related to lipid profile promotion, and hence to CVD prevention.[7-10]

The previous studies have shown that a vegetarian diet compared with an omnivorous one has an inverse association with lipid profiles.[11,12] Vegetarian diet provide higher amount of fruits, vegetables, whole grains, nuts and soy, all of which are associated with lower risk of CVD through lipid profile reduction.[13-15] Phytochemicals such as phytosterols and phenolic compounds are bioactive compounds that are found abundantly in plant foods and protect against cardiovascular events by reducing prothrombic and inflammatory status and improving endothelial function.[16] It has been suggested that phytochemicals have an important role in lipid metabolism that causing decrease in lipid profile.[17] Regarding health-promotional properties of phytochemicals, for the first time, McCarty proposed a "phytochemical index" (PI), defined as the percent of dietary calories derived from foods rich in phytochemicals, and suggested that PI could be used as an index of total dietary phytochemical content.[18] This index is a simple method for assessment of phytochemical intake that, despite its limitations, could provide important background for diet quality and may have high practical and clinical uses.[19] Previous clinical trials have documented beneficial effect of phytochemical supplements on lipid profile.[20-23] Recently, in a cross-sectional study, we have indicated that subjects in higher quartile of dietary PI intake have lower risk of hypertriglyceridemia [0.36, 95% confidence interval (CI) = 0.47-0.86].[24] However, to our knowledge, no prospective population-based studies of PI and lipid profile have been published. Therefore, in this population-based longitudinal study, we assessed the baseline dietary PI in relation to 3 years changes of lipid and lipoprotein levels among Tehranian adults.

Materials and Methods

Study design and subjects

This study was conducted within the framework of the Tehran Lipid and Glucose Study (TLGS) in Iran.[25] Briefly, TLGS, a community-based prospective study that began in 1999 and data collection is ongoing at 3-year intervals, is being conducted to investigate and prevent non-communicable diseases (NCDs) by promoting healthy lifestyles and reducing NCD risk factors in a representative sample of residents, aged ≥ 3 years, from district 13 of Tehran, Iran. Baseline examination of the current study was included 2799 adults aged 19-70 years with complete data (demographic, anthropometric, biochemical, and dietary data), participated in the third phase of TLGS (2006-2008). Participants were excluded from the final analysis if they reported implausible energy intake (< 800 kcal/d or ≥ 4200 kcal/d), were on specific diets (n = 232), or had no follow-up information on anthropometrics and biochemical measurements at the second examination (2009-2011) (n = 629); finally 1938 participants (845 men and 1093 women) were included in the analysis. The mean duration of the follow-up was approximately 3 years.

Informed written consents were obtained from all participants and the study protocol was approved by the research council of the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences.

Dietary assessment and PI calculation

Dietary data were collected by using a validated semi-quantitative food frequency questionnaire (FFQ) with 168 food items[26] at baseline. Trained dietitians with at least 5 years of experience in the TLGS survey interviewed participants, face to face, and asked them about their consumption frequency for each food item consumed during the past year on a daily, weekly, or monthly basis. The validity of the FFQ was previously evaluated by comparing food groups and nutrient values determined from the questionnaire with values estimated from the average of twelve 24-h dietary recall surveys.[26,27] Portion sizes of consumed foods that were reported in household measures were then converted to grams. The United States Department of Agriculture (USDA) food composition table (FCT) was used to calculated energy and nutrient intakes. The Iranian food composition table was also used for some national foods that are not listed in the USDA FCT.[28,29]

PI was calculated based on the McCarty equation:[18]

$$PI = \frac{\text{dietary energy derived from phytochemicalon ported in house}}{\text{total daily energy intake (kcal)}} \times 100$$

Fruits and natural fruit juices, vegetables and natural vegetables juices, whole grains, legumes, nuts, seeds, olives, and olive oil were defined as phytochemical-rich foods.

Lifestyle assessment

Lifestyle data, including physical activity level, smoking status, and educational level were collected at baseline. Physical activity level was assessed using

the Krishka et al. questionnaire.[30] The frequency and time spent on light, moderate, hard and very hard intensity activities, according to the list of common activities of daily life, over the past year were obtained. Physical activity levels were expressed as metabolic equivalent hours per week (METs h/week). Subjects who had smoked daily or occasionally were considered to be current smokers and those who had never smoked or those who given up smoking as non-smokers.

Laboratory measurements

Blood samples were taken after 12-14 h overnight fasting at baseline and after 3 years. Total cholesterol level was measured using enzymatic colorimetric analysis with cholesterol esterase/cholesterol oxidase. Triglyceride level was measured using by enzymatic colorimetric analysis with glycerol phosphate oxidase. HDL-C was measured after precipitation of the Apo B containing lipoproteins with phosphotungstic acid. LDL-C was calculated according to the Friedwald equation if triglyceride concentration was less than 400 mg/dl. Analyses were performed using Pars Azmoon kits (Pars Azmoon Inc., Tehran, Iran) and a selectra 2 auto-analyzer (Vital Scientific, Spankeren, The Netherlands). Inter- and intra-assay coefficients of variation of all assays were all < 5%.

Statistical analysis

Dietary PI at baseline was divided into quartiles; participant characteristics, and baseline and 3 years changes of lipid and lipoprotein levels, were compared across quartile categories of PI, using the general linear models adjusted for age or the chi-square test. The mean dietary intakes of participants were compared across quartile categories of PI using general linear model with adjustment for age and energy intake. To assess the overall trends of the lipid and lipoprotein mean across PI quartiles, the median of PI in each quartile was used as a continuous variable in the logistic regression models. The mean of 3 years changes in lipid and lipoprotein levels were calculated as [(second levels−baseline levels)/baseline levels]. Multiple regression models were used to evaluate the association between dietary PI and changes in serum total cholesterol, triglycerides, LDL-C and HDL-C. Subjects in the first PI quartile were considered as the reference group. To determine the association between each phytochemical-rich food groups with 3 years changes in lipid profile, we also categorized energy adjusted intakes of whole grains, vegetables, fruits, legumes, nuts, soy, olives and olive oil, into quartiles. Mean change of each lipid profile measure associated with each category of dietary PI or phytochemical-rich food, compared with the reference group and their 95% CIs were estimated by using the multiple regression models with adjustment for potential confounder variables. The variables adjusted in the models were sex, age at baseline (years, continuous), body mass index (kg/m², continuous), education (four categories), smoking (yes or no), physical activity (MET-h/week, continuous), total energy intake (kcal/d), dietary carbohydrate (% of energy), fat (% of energy), and protein (% of energy). A linear trend test was performed by considering each ordinal score variable as a continuous variable in the model. All statistical analysis were conducted using the SPSS for Windows (version 16.0; SPSS Inc., Chicago, IL, USA), with *P*-values < 0.05 was considered as significant.

Results

The mean age of participants at baseline was 41.4 ± 13.5 and 39.6 ± 12.6 years in men and women, respectively; about 53% of participants were women. The mean 3-year changes were: serum cholesterol 1.1 ± 1.0 mg/dl in men and 1.9 ± 0.9 mg/dl in women; triglycerides −5.8 ± 2.8 and −4.9 ± 1.7 mg/dl; HDL-C 4.1 ± 0.2 mg/dl and 5.9 ± 0.2 mg/dl and LDL-C −1.9 ± 0.9 and −3.0 ± 0.8 mg/dl in men and women, respectively.

The mean PI was 29.8 ± 12.3; 28.5 ± 12.1 in men, and 30.9 ± 12.3 in women. The dietary PI ranged from 19.6 to 35.5 in men and 21.8 to 37.9 in women (Table 1). Participants in the highest PI quartile category were more likely to be older compared with the lowest PI quartile (35 vs. 48 years in men and 36 vs. 45 in women, P for trend < 0.001).

Lipid and lipoprotein levels of participants by categories of dietary PI at baseline and after 3 years of follow-up are presented in table 2. After 3 years of follow-up, total cholesterol levels were significantly lower in the highest compared with the lowest PI quartile category in men (181 ± 3 vs. 189 ± 3 mg/dl, *P* for trend < 0.05); moreover, 3 years change of total cholesterol was inversely associated with dietary PI (3.9 ± 2.1 mg/dl decrease in the highest PI quartile vs. 4.3 ± 2.1 mg/dl increase in the lowest PI quartile, P for trend < 0.05). At baseline and after 3-year level of triglyceride decreased across quartile of PI in men and women, but were not significant. HDL-C level had not significant changes across quartile of PI in men and women at baseline and after 3 years. LDL-C level decreased across quartile of PI in men and

women at baseline and after 3 years, but it was not constant. The levels of triglyceride, HDL-C, and LDL-C had not significant changes across the PI quartile during the 3-year follow-up.

Table 1. Demographic characteristics of participants by categories of dietary phytochemical index: Tehran Lipid and Glucose Study

Demographic characteristics	Dietary phytochemical index							
	Men				Women			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Dietary phytochemical index								
Range	< 19.6	19.6-27.0	27.1-35.5	> 35.5	< 21.8	21.8-29.6	29.7-37.9	> 37.9
Mean	16.5 ± 0.5	24.7 ± 0.5	31.4 ± 0.5	41.1 ± 0.5	19.1 ± 0.4	26.8 ± 0.4	34.5 ± 0.4	43.2 ± 0.4
Age 2006-2008 (year)	35.1 ± 0.8	39.2 ± 0.8	42.9 ± 0.8	48.4 ± 0.8[*]	36.6 ± 0.7	37.2 ± 0.7	39.3 ± 0.7	45.2 ± 0.7[*]
Physical activity (MET-h/week)								
Job activity	38.9 ± 4.7	27.1 ± 4.5	31.4 ± 4.5	23.1 ± 4.7	23.2 ± 2.2	24.6 ± 2.2	23.4 ± 2.2	20.6 ± 2.3
Leisure time activity	10.4 ± 1.3	13.4 ± 1.3	9.5 ± 1.3	13.0 ± 1.3	8.5 ± 0.8	8.2 ± 0.7	10.0 ± 0.7	9.0 ± 0.8
Total	49.4 ± 4.9	40.5 ± 4.7	41.0 ± 4.7	36.1 ± 4.9	31.7 ± 2.4	32.8 ± 2.4	33.4 ± 2.4	29.6 ± 2.4
Current smoker (%)	24.9	24.5	24.2	18.5	1.8	2.2	0.4	3.3
Education status (%)								
Illiterate	1.4	0.9	1.0	1.4	2.2	2.6	3.3	4.4
Primary education	10.0	7.1	0.0	11.1	0.0	10.7	0.0	0.0
Academic education	80.0	85.8	78.6	66.7	92.0	82.2	95.0	100.0
Advanced academic education	10.0	7.1	21.4	22.2	8.0	7.1	5.0	0.0

Mean ± SEM; [*] P < 0.05 (chi-square test or age-adjusted general linear models were used); SEM: Standard error of mean

Table 2. Lipid profile of participants by categories of dietary phytochemical index at baseline and after 3 years of follow-up: Tehran Lipid and Glucose Study

Lipid profile	Dietary phytochemical index							
	Men				Women			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Triglycerides (mg/dl)								
Baseline	161 ± 7	167 ± 7	158 ± 7	155 ± 7	132 ± 4	126 ± 4	127 ± 4	130 ± 4
After 3-years	158 ± 7	166 ± 7	150 ± 7	144 ± 7	127 ± 4	122 ± 4	124 ± 4	124 ± 4
Changes	-2.7 ± 5.9	-1.5 ± 5.7	-8.1 ± 5.7	-10.8 ± 5.9	-5.4 ± 3.4	-3.9 ± 3.4	-4.7 ± 3.4	-5.7 ± 3.5
Total cholesterol (mg/dl)								
Baseline	185 ± 3	190 ± 3	183 ± 3	185 ± 3	186 ± 2	187 ± 2	189 ± 2	184 ± 2
After 3-years	189 ± 3	192 ± 3	185 ± 3	181 ± 3[*]	189 ± 2	188 ± 2	190 ± 2	185 ± 2
Changes	4.3 ± 2.1	2.3 ± 2.0	1.6 ± 2.0	-3.9 ± 2.1[*]	3.5 ± 1.8	1.2 ± 1.8	1.7 ± 1.8	1.2 ± 1.9
HDL-C (mg/dl)								
Baseline	38.0 ± 0.6	38.1 ± 0.5	38.1 ± 0.5	38.4 ± 0.6	45.6 ± 0.6	45.7 ± 0.6	45.5 ± 0.6	44.8 ± 0.6
After 3-years	42.0 ± 0.6	42.8 ± 0.6	41.8 ± 0.6	42.3 ± 0.6	51.0 ± 0.7	51.8 ± 0.6	51.6 ± 0.6	51.0 ± 0.7
Changes	4.0 ± 0.4	4.6 ± 0.4	3.7 ± 0.4	3.9 ± 0.4	5.4 ± 0.5	6.1 ± 0.5	6.0 ± 0.5	6.1 ± 0.5
LDL-C (mg/dl)								
Baseline	116 ± 2	120 ± 2	113 ± 2	115 ± 2	115 ± 2	116 ± 2	117 ± 2	113 ± 2
After 3-years	116 ± 2	117 ± 2	113 ± 2	110 ± 2	113 ± 2	112 ± 2	114 ± 2	109 ± 2
Changes	0.9 ± 1.8	-2.7 ± 1.8	-0.2 ± 1.8	-5.5 ± 1.8	-1.2 ± 1.6	-4.1 ± 1.6	-3.4 ± 1.6	-3.4 ± 1.6

Mean ± SEM; [*] P < 0.05 (age-adjusted general linear models were used); SEM: Standard error of mean; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol

The mean dietary intake of men and women across dietary PI quartile categories are presented in table 3. Dietary energy and fat intake decreased significantly across quartiles of PI (P for trend < 0.001), while dietary intake of carbohydrate, protein, and vitamin C significantly increased (P for trend < 0.001) in both men and women. Dietary intakes of whole grains, fruits, vegetables, seeds, nuts, and olive oil in the highest quartile category of PI, were significantly higher than the lowest quartile categories in men and women.

The associations between baseline PI with 3 years changes in total cholesterol, triglycerides, LDL-C, and HDL-C adult participants are shown in table 4. After adjustment for potential confounding variables, there was significant inverse association between highest quartile category of dietary PI with changes in triglycerides, total cholesterol, HDL-C, and non-HDL-C in men (P for trend < 0.01), while dietary PI had no significant association with changes in lipid profile across quartile categories in women.

Discussion

In this first longitudinal study of PI and lipid profile, we found that increased energy intakes from phytochemical rich foods, presented as dietary PI, could have favorable effects on subsequent changes of triglycerides, total cholesterol, and non-HDL-C levels in men. In addition, during the follow-up, we found a significant reduction in the total cholesterol levels in men who had higher phytochemicals index. No significant association was observed between dietary PI and 3 years changes of lipid and lipoprotein levels.

It is well-known that non-pharmacological agents such as bioactive food components and functional foods can improve lipid profile.[31] Epidemiologic evidence indicate that the incidence of cardiovascular disease is lower in populations who consume phytochemical-rich diet; this effects are mainly attributed to functional properties of phytochemicals including improvement of lipid profile, anti-inflammatory, anti-prothrombotic and anti-oxidative properties.[32-36] The Mediterranean diet is the best example of a phytochemical-rich diet; recently, two studies have reported that Mediterranean and phytochemicals-rich diets reduce total cholesterol, LDL-C and non-HDL-C levels, but their decrease was greater in phytochemicals-rich diet than in

the Mediterranean diet. Besides, HDL-C level has increased only in phytochemicals-rich diet.[10,37] Lukaczer et al.[38] have demonstrated that phytochemicals-rich diet is more effective than American Heart Association diets to manage lipid profiles. These findings suggest that phytochemicals may have further effect on lipid profile improvement.

It has suggested that phytosterols are responsible for phytochemical-related lipid reduction. Phytosterols are a subclass of phytochemicals with potent lipid lowering properties; several studies have evaluated cholesterol-lowering effect of phytosterols.[39,40] Studies showed that enrichment of food products with phytosterols could effectively improve lipid and lipoprotein levels.[41,42] Main mechanism by which phytosterols reduce cholesterol by competing with cholesterol for micellar incorporation, hence inhibiting its intestinal uptake, however the reason of LDL-C reduction is unknown.[43] It seems, frequency of phytosterols intake, also, affects cholesterol level as multiple-consumption of these has a greater effect compared with single-consumption.[39]

Moreover, some phytochemicals bind to peroxisome proliferator-activated receptors which regulate lipid metabolism, promote uptake, utilization, and catabolism of fatty acids by up-regulation of genes involved in fatty acid transport and peroxisomal and mitochondrial fatty acid β-oxidation.[17] In addition, animal studies have shown that phytosterols up-regulate hepatic ABCG5 transporters and result in cholesterol reduction.[44]

Conflict of Interests

Authors have no conflict of interests.

Table 3. Mean dietary intakes of participants by categories of dietary phytochemical index: Tehran Lipid and Glucose Study

Dietary intake	Dietary phytochemical index							
	Men				Women			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Energy intake (kcal/d)	2869 ± 41	2513 ± 40	2242 ± 40	1950 ± 41[*]	2618 ± 32	2252 ± 32	2131.0 ± 32.0	1724 ± 32[*]
Carbohydrate (% of total energy)	56.3 ± 0.4	57.9 ± 0.4	60.2 ± 0.4	61.9 ± 0.4[*]	52.9 ± 0.4	55.3 ± 0.4	57.1 ± 0.4	60.8 ± 0.4[*]
Fat (% of total energy)	31.6 ± 0.4	30.4 ± 0.4	28.9 ± 0.4	27.5 ± 0.4[*]	35.2 ± 0.4	33.4 ± 0.4	32.3 ± 0.4	29.3 ± 0.4[*]
Saturated fat (g/d)	29.9 ± 1.3	26.9 ± 1.3	26.4 ± 1.3	23.6 ± 1.4[*]	28.7 ± 0.5	27.2 ± 0.5	26.8 ± 0.5	23.0 ± 0.5[*]
Monounsaturated fat (g/d)	28.1 ± 0.5	28.1 ± 0.5	27.0 ± 0.5	25.2 ± 0.5[*]	29.5 ± 0.5	28.8 ± 0.5	28.2 ± 0.5	24.6 ± 0.5[*]
Polyunsaturated fat (g/d)	17.3 ± 0.4	17.3 ± 0.4	16.1 ± 0.4	15.2 ± 0.4[*]	18.3 ± 0.4	17.8 ± 0.4	16.9 ± 0.4	14.6 ± 0.4[*]
Protein (% of total energy)	12.9 ± 0.1	13.6 ± 0.1	13.6 ± 0.1	14.4 ± 0.1[*]	12.9 ± 0.1	13.5 ± 0.1	13.7 ± 0.1	14.3 ± 0.1[*]
Total fiber (g/d)	39.0 ± 1.4	40.1 ± 1.3	40.1 ± 1.3	43.4 ± 1.4	32.2 ± 0.9	35.4 ± 0.8	37.6 ± 0.8	38.9 ± 0.9[*]
Total carotenoids (µg/d)	6524 ± 385	8986 ± 349	9980 ± 350	11225 ± 384[*]	6919 ± 416	9573.0 ± 383	12457 ± 382	13588 ± 426[*]
Vitamin E (mg/d)	10.7 ± 0.3	11.6 ± 0.3	11.6 ± 0.3	11.6 ± 0.3	11.7 ± 0.3	11.9 ± 0.3	12.1 ± 0.3	11.9 ± 0.3
Vitamin C (mg/d)	77.2 ± 5.5	135.7 ± 5.0	164.0 ± 5.0	177.8 ± 5.5[*]	89.3 ± 5.0	144.1 ± 4.6	175.0 ± 4.6	201.8 ± 5.1[*]
Whole grains (g/d)	10.2 ± 6.4	75.1 ± 5.8	134.9 ± 5.8	208.3 ± 6.4[*]	8.7 ± 5.1	60.0 ± 4.7	110.0 ± 4.6	154.3 ± 5.2[*]
Fruits (g/d)	142 ± 17	343 ± 16	450 ± 16	502 ± 17[*]	178 ± 15	378.0 ± 14	430 ± 14	559 ± 15[*]
Vegetables (g/d)	202 ± 11	258 ± 10	284 ± 10	311 ± 11[*]	238 ± 13	288.0 ± 12	374 ± 12	384 ± 13[*]
Legumes (g/d)	13.3 ± 1.8	16.9 ± 1.6	17.6 ± 1.6	17.8 ± 1.8[*]	10.7 ± 1.1	14.5 ± 1.0	17.3 ± 1.0	17.3 ± 1.2[*]
Seeds (g/d)	0.4 ± 0.4	2.1 ± 0.4	2.1 ± 0.4	3.4 ± 0.4[*]	0.3 ± 0.3	1.7 ± 0.3	1.5 ± 0.3	3.0 ± 0.3[*]
Nuts (g/d)	3.7 ± 0.7	6.2 ± 0.7	10.2 ± 0.7	11.0 ± 0.7[*]	3.0 ± 0.5	6.9 ± 0.5	7.4 ± 0.5	9.5 ± 0.5[*]
Olive oil (g/d)	0.2 ± 0.1	0.5 ± 0.09	0.7 ± 0.09	0.9 ± 0.1[*]	0.1 ± 0.1	0.6 ± 0.1	1.1 ± 0.1	1.6 ± 0.2[*]
Soy sources (g/d)	0.6 ± 0.3	1.8 ± 0.2	1.3 ± 0.3	2.2 ± 0.3[*]	1.3 ± 0.4	1.9 ± 0.3	1.5 ± 0.3	2.8 ± 0.4

Mean ± SEM; [*] P < 0.05 (age- and energy-adjusted models were used); SEM: Standard error of mean

Table 4. The association of dietary phytochemical index with 3 years changes in lipid profiles in Iranian adults: Tehran Lipid and Glucose Study[*]

3-year lipid profile changes	Dietary phytochemical index					
	Men			Women		
	Q2	Q3	Q4	Q2	Q3	Q4
Triglycerides	−6.0 (−15.1, 2.9)	−11.4 (−21.1, −1.8)	−13.7 (−24.6, −2.8)[**]	−0.8 (−7.8, 6.1)	−0.2 (−7.5, 7.1)	−4.3 (−12.9, 4.3)
Total cholesterol	−1.6 (−4.7, 1.5)	−2.5 (−5.9, 0.8)	−5.6 (−9.3, −1.8)[**]	−1.6 (−4.4, 1.2)	−0.8 (−3.6, 2.2)	−1.7 (−5.1, 1.73)
HDL-C	0.7 (−2.6, 4.1)	−3.1 (−6.6, 0.5)	−3.6 (−7.7, 0.4)	0.8 (−2.9, 4.4)	0.4 (−3.4, 4.2)	−0.2 (−4.8, 4.3)
LDL-C	−2.7 (−7.5, 2.0)	−0.6 (−5.7, 4.5)	−4.9 (−10.7, 0.8)	−2.5 (−6.6, 1.6)	−0.9 (−5.2, 3.5)	0.7 (−4.5, 5.8)
Non-HDL-C	−2.5 (−6.3, 1.4)	−2.8 (−6.9, 1.3)	−6.2 (−10.8, −1.5)[**]	−2.5 (−6.1, 1.1)	−1.1 (−4.8, 2.6)	−1.9 (−6.4, 2.5)
Total cholesterol/HDL-C	−2.2 (−5.7, 1.4)	−0.2 (−4.1, 3.6)	−2.3 (−6.7, 1.9)	−1.7 (−5.0, 1.6)	−1.5 (−4.9, 2.0)	−1.2 (−5.3, 2.9)
LDL-C/HDL-C	3.6 (−8.6, 1.4)	1.5 (−3.8, 6.8)	−2.2 (−8.2, 3.7)	−2.3 (−7.1, 2.4)	−1.9 (−7.0, 3.1)	1.0 (−4.9, 7.0)
Triglyceride/HDL-C	−6.4 (−16.3, 3.6)	−9.1 (−19.7, 1.6)	−10.7 (−22.7, 1.3)	−1.2 (−9.1, 6.7)	−2.0 (−10.3, 6.2)	−4.1 (−13.9, 5.7)

Q1 was considered as reference group; [*] Data are β regression and 95% confidence interval [linear regression models were used with adjustment for age, total energy intake (kcal/d), dietary carbohydrate (% of energy), fat (% of energy), protein (% of energy), saturated fatty acid (kcal/d), mono-saturated fatty acid (kcal/d) and poly-saturated fatty acid (kcal/d)]; [**] P for trend < 0.05; Medians of dietary phytochemical index quartiles in men were 16.3, 24.4, 30.7, and 35.5 in the first, second, third, and fourth quartile categories, respectively and in women were 18.9, 25.3, 33.2, and 37.9 in the first, second, third, and fourth quartile categories, respectively; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol

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