Original Article

Legume Intake is Inversely Associated with Metabolic Syndrome in Adults

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Abstract

Background: Studies on the association between legume intake and metabolic syndrome (MetS) are sparse. The objective of this study is to evaluate the association between legume intake, MetS, and its components.

Methods: This study was conducted on 80 subjects (48% female) with MetS as cases and 160 age and gender-matched healthy controls. Anthropometric measures, blood pressure, fasting blood glucose, and lipid profiles were evaluated by standard methods. Dietary data were collected using a food frequency questionnaire (FFQ) and legume intake was determined. MetS was defined according to the definition of the Adult Treatment Panel III.

Results: The mean (SD) intake of legumes was 1.4 (0.9) servings/week for cases and 2.3 (1.1) servings/week for control subjects ($P < 0.05$). After adjustment for potential confounders, decreases in mean systolic blood pressure, fasting blood glucose, and increase in HDL cholesterol levels were observed across increasing quartile categories of legume intake. After adjustments for life style and food groups, subjects in the highest quartile of legume intake had lower odds of having MetS compared with those in the lowest quartile [odds ratio (OR): 0.25; 95% CI: 0.11 – 0.64, $P < 0.05$], an association that weakened after adjustment for body mass index (BMI), but remained significant (OR: 0.28; 95% CI: 0.12 – 0.81, $P < 0.05$).

Conclusions: Legume intake is inversely associated with the risk of having MetS and some of its components.

Keywords: Adult, case-control study, legume intake, metabolic syndrome

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Introduction

Metabolic syndrome (MetS) refers to the constellation of metabolic abnormalities that include glucose intolerance, abdominal obesity, dyslipidemia, and hypertension.[1] Among several contributing factors that influence the prevalence of MetS,[2,3] dietary factors play an important role in development or prevention of this syndrome. Dietary factors such as whole grains, dairy products, fruits and vegetables have an inverse association, whereas hydrogenated vegetable oils and red meat are positively associated with this syndrome.[4–8] Among dietary determinants, legumes constitute a food group that has been reported to protect against the development of diabetes,[9] cardiovascular disease,[10] and cancer.[11] Although, the Mediterranean dietary pattern or other dietary patterns that include increased legume intake have been shown to be inversely associated with MetS,[12–14] limited data are available on the association between legume intake and MetS.[12] Therefore, the aim of this study is to determine the association between legume intake, MetS, and its components.

Materials and Methods

Study population

This observational case-control study was conducted on individuals who referred to the outpatient clinics of Taleghani Hospital over a six-month period, between February and July 2009. Both cases and controls were selected from among persons who accompanied patients to the vaccination and dental clinics of this hospital. Initial criteria for eligible subjects were as follows: age 25 – 55 years; no change in diet in the past year; no use of corticosteroid medications three months prior to study entry; no use of other medications such as aspirin or multivitamins; and no history of cardiovascular disease, diabetes, cancer, or stroke because of possible changes in diet associated with these conditions. The case group consisted of subjects diagnosed with MetS, as defined by the third report of the National Cholesterol Education Program Adult Treatment Panel III,[1] and included three or more of the following components: high serum triglyceride concentrations (≥ 150 mg/dl and/or use of hypotriglyceridemic medication); low serum HDL cholesterol concentrations (< 40 mg/dl in men and <50 mg/dl in women); elevated blood pressure (≥ 130/85 mmHg and/or use of hypertensive medication); abnormal glucose homeostasis (fasting plasma glucose ≥ 100 mg/dl and/or use of insulin or oral hypoglycemic medication); and enlarged waist circumference. The cutoffs

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for enlarged waist circumference were set at > 89 cm in men and > 91 cm in women, based on guidelines for the First Nationwide Study of the Prevalence of Metabolic Syndrome in Iran.[15] Controls were accompanying persons (both healthy individuals who accompanied MetS patients and other patients seen in the clinics for various reasons) with less than three risk factors from ATP III criteria, selected from the same clinics as the cases. We selected two individual age- (±1 year) and gender-matched controls per case. This study included 39 women and 41 men with MetS as cases, and 78 women and 82 men without MetS as the control group. The Ethics Committee of the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences approved the study protocol and informed written consent was obtained from each subject.

Assessment of dietary intake

To assess the usual dietary intake during the past year, we used a valid and reliable semi-quantitative food frequency questionnaire (FFQ),[16] which included 168 items of foods with standard serving sizes, as commonly consumed by Iranians. The frequency of consumption of each food item was questioned on a daily, weekly or monthly basis and converted to daily intakes; the portion sizes were then converted to grams using household measures.[17] Then, the FFQ food items as based on their nutrient contents were categorized into food groups, which included fruits, vegetables, meats and fish, whole grains, refined grains, dairy products, and nuts. Due to the incompleteness of the Iranian Food Composition Table (FCT), we used the US Department of Agriculture (USDA) FCT to analyze foods and beverages for their energy and nutrient content.[18] However, the Iranian FCT was used for some dairy products (i.e., *kashk*) not listed in the USDA FCT.

Legume intake included cooked lentils, beans, chickpeas, cooked broad beans, soy beans, mung beans, and split peas. Intake of each legume was calculated as grams per week and then adjusted for total energy intake by the residual method, as described by Willett and Stampfer;[19] after which, this energy adjusted legume intake was converted to weekly intakes of servings.[20]

Assessment of biomarkers

Blood samples were drawn from subjects after ten hours overnight fasting. Fasting plasma glucose was measured by the enzymatic colorimetric method using the glucose oxidase technique. Serum triglyceride concentrations were measured with the use of triglyceride kits (Pars Azmon Inc., Tehran, Iran) by enzymatic colorimetric tests with glycerol phosphate oxidase. HDL cholesterol was measured after precipitation of the apolipoprotein B-containing lipoproteins with phosphotungestic acid.

Assessment of anthropometric measures and blood pressure

Weight was measured while the subjects were minimally clothed and not wearing shoes, by using digital scales which were calibrated weekly. Height was measured with a tape measure while the subjects were in a standing position, without shoes, and with the shoulders in a normal position. Body mass index (BMI) was calculated from weight divided by height squared (kg/m^2). Waist circumference was measured at the level of the umbilicus with the use of an outstretched tape measure without pressure to the body surface. Blood pressure was measured using a standardized mercury sphygmomanometer, on the right arm after a 15-minute rest with the patient in a sitting position. Two measurements were taken at one minute intervals and the average of the measurements was considered as the participant's blood pressure. To reduce subjective error, all measurements were taken by the same technician.

Assessment of other variables

We used a questionnaire to obtain the following information: age, smoking status, educational level and current medication use of oral hypoglycemics, insulin, antihypertensives, and hypotriglyceridemic drugs. The questionnaire also gathered information regarding estrogen use and medications which increase HDL cholesterol levels. Physical activity was assessed by a questionnaire that included a list of common activities of daily life.[21] The frequency and amount of time spent on activities per week over the past 12 months were documented. Level of physical activity was expressed as metabolic equivalent hours per week (METs h/wk).[22] Cigarette smoking status was categorized as current, non-, and ex-smoker. In this study, subjects who reported daily energy intakes outside the 800 to 4000 kcal/d range were excluded.

Statistical methods

Statistical analyses were conducted using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA), Statistical Data Analysis version 8 (STATA crop, TX, USA), and SAS software, version 9.1.3 (SAS Institute Inc., Cary, NC, USA). Normality of distribution for continuous variables that included serum triglycerides and HDL cholesterol concentrations, blood pressure, fasting plasma glucose, waist circumference, and dietary intakes was assessed by the Anderson-Darling test using SAS software; all variables had normal distributions. The baseline components of MetS and characteristics were compared between cases and controls by independent sample t-test and Chi-square test. Controls were divided into four groups according to the quartiles of energy-adjusted legume intake, the cutoffs of which were: ≤ 1.0, 1.1 to 1.7, 1.8 to 2.9, and ≥ 3.0 serving/weekly for quartiles 1 – 4, respectively and were used as cut points to categorize cases. Energy adjusted-means for dietary intakes were determined across quartiles of legume intake using a general linear model. The general linear model was used to assess components of MetS across quartiles of energy-adjusted legume intake and to estimate the *P* for trend in means of components of MetS across quartiles of energy-adjusted legume intake. Conditional logistic regression was used to calculate the odds ratios (ORs) and 95% CIs for MetS, with individuals in the lowest quartile category of legume intake as the reference category, using STATA. $P < 0.05$ was considered statistically significant.

To determine the association of energy adjusted legume intake with metabolic risks and its components, we used multivariable models controlled for physical activity (METs h/wk), smoking status (current, non-, and ex-smoker), education level (illiterate and primary school, high school graduate, college and over), total fiber (g/d), magnesium (mg/d) and BMI (kg/m^2). For dietary variables, we further examined whether intakes of food groups associated with legume intake would explain these associations. The correlation coefficients between legume intake and food groups were calculated using Pearson correlation. Legume intake was significantly associated with vegetables (r = 0.3); fruits (r = 0.3); whole grains (r = 0.4); dairy products (r = 0.4); meat, fish and poultry (r = 0.4); and nuts (r = 0.1). There was a significant difference between intakes of fruit and dairy products between cases and controls, using the independent sample t-test. Therefore, we assessed the association between legume intake and MetS and its components by further

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Table 1. Results of propensity scoring in case and control groups

Groups	Mean (SD)	Minimum	Maximum
Case	0.3240 (0.0886)	0.0173	0.568
Control	0.3514 (0.0853)	0.0177	0.572
Total	**0.3338 (0.0882)**	**0.0173**	**0.572**

Table 2. Characteristics and dietary intake of subjects with metabolic syndrome (MetS) and controls.

Variables	Cases (n=80)	Controls (n=160)	*P* value
Baseline characteristics			
Number of participants (men/women)	(41/39)	(82/78)	
Age (years)	41.4±8.3	41.4±7.7	0.974
Weight (kg)	92.6±12.3	82.9±10.4	0.012
BMI (kg/m^2)	27.8±3.3	25.3±3.6	0.002
Serum triglyceride concentrations (mg/L)	174±36	110±28	0.014
HDL cholesterol concentrations (mg/L)	36.8±7.0	43.3±8.1	0.025
Fasting blood glucose (mg/L)	97.4±7.8	90.4±6.6	0.036
Systolic blood pressure (mmHg)	115±11.9	107±12.1	0.045
Diastolic blood pressure (mmHg)	76.5±9.2	71.1±8.5	0.014
Waist circumference (cm)	97.0±7.2	87.3±10.4	0.028
Physical activity (METs h/wk)	12.2±2.9	13.5±4.0	0.008
Current estrogen use (%)	12%	16%	0.254
Smoking status (%)			
Never smoked	77.5	82.5	0.631
Ex-smokers	6.3	4.4	
Current smokers	16.2	13.1	
Education levels (%)			
Illiterate and primary school	45.0	43.8	0.814
High school graduate	40.6	40.0	
College and over	14.4	16.2	
Dietary intakes (g/d)			
Legumes	19.6±1.9	18.5±1.7	<0.005
Vegetables	244±112	269±148	0.182
Fruits	309±199	380±236	0.021
Whole grain	78±55	84±49	0.429
Dairy products	305±198	354±196	0.074
Meat, fish and poultry	57.2±27.1	57.8±26.6	0.862
Nuts	8.6±6.8	10.0±7.8	0.194

BMI: Body mass index; METs h/wk: Metabolic equivalent hours per week. Continuous values are mean (SD).

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adjusting for the intakes of fruits and dairy products. In all multivariate models, the first quartile of energy adjusted legume intake was considered as a reference.

We also determined the propensity score using physical activity (METs h/wk), smoking status (current, non-, and ex-smoker), education level (illiterate and primary school, high school graduate, college and over), fruits (g/d), dairy products (g/d), total fiber (g/d), magnesium (g/d) and BMI (kg/m^2) as variables by the logit model using STATA software. The propensity scores for cases and controls were ranked separately from less to more. The cases were matched to controls using a propensity score with an acceptable range of ≤ 0.04, excluding subjects beyond this range. Finally using a propensity score, data for 72 cases and 129 controls remained for analysis. The results of the propensity scores are shown in Table 1. The model adequacy was determined by Hosmer-Lemeshow ($P = 0.72$). After the second analysis following propensity scoring, results were similar to results of individual matching [two individual age- (±1 year) and gender-matched controls per case].

Results

The study included 39 women and 41 men with MetS as cases, and 78 women and 82 men in the control group, with an average of 41.4 ± 7.9 years. The mean intakes of legumes were 1.4 ± 0.9 servings per day for cases and 2.3 ± 1.1 servings per day for control subjects ($P < 0.05$). Characteristics of the study subjects in case and control groups are shown in Table 2. Weight, BMI, waist circumference, fasting blood glucose, serum triglyceride concentrations, as well as systolic and diastolic blood pressures were significantly higher in subjects with MetS, whereas HDL cholesterol levels were significantly lower in those with MetS. In the case group, 73.8% of cases had three risk factors, 20.0% had four risk factors, and 6.2% had five risk factors. Of controls, 19.4% had no risk factors, whereas 30.6% had one risk factor, and 50.0% had two risk factors. There were no significant differences in smoking habits, education levels, and current use of estrogen observed between the case and control groups.

Energy-adjusted means for dietary variables across quartile categories of legume intake are shown in Table 3. Subjects in the higher quartile of legume intake consumed more fruits, vegetables, meats and fish, whole grains, dairy products, cholesterol, total fiber and magnesium.

Figure 1 shows the mean components of MetS according to quartiles of legume intake. After adjustments for lifestyle and fruit and vegetable variables, decreases were observed in fasting blood glucose, waist circumference, and systolic blood pressure and increases observed in HDL cholesterol levels across increasing quartiles of legume intake. These associations all remained significant after

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Table 3. Dietary intake of subjects by quartiles of legume intake.[1]

Variables	Quartile of energy-adjusted legumes intake				P
	1	2	3	4	
Range of legumes intake (servings/wk)	≤1.0	1.1–1.7	1.8–2.9	≥3.0	
Median legumes intake (servings/wk)	0.8	1.2	2.1	3.2	
Metabolic syndrome (MetS) cases (n)	35	26	11	8	
Nutrients					
Total energy (kcal/d)	1409±253[2]	1952±27	2470±31	3309±32	0.024
Carbohydrate (% of total energy)	57.1±3.7	57.0±2.1	62.6±2.5	77.5±5.4	0.012
Protein (% of total energy)	13.1±0.9	13.2±0.5	15.2±0.6	19.6±1.3	0.028
Fat (% of total energy)	14.7±1.1	14.1±0.6	15.3±0.7	17.4±1.6	0.017
Cholesterol (mg/d)	170±19	192±10	247±12	301±27	0.016
Total dietary fiber (g/d)	30.6±1.6	32.1±1.7	38.6±1.9	45.9±2.00	0.027
Vitamin B-6 (mg/d)	1.7±0.1	1.8±0.1	2.0±0.1	2.3±0.2	0.023
Magnesium (mg/d)	360±22	371±12	385±14	396±32	0.028
Foods (g/d)					
Fruit[3]	273±250	354±26	401±30	442±31	0.015
Vegetables[4]	214±15	239±16	312±18	311±18	0.045
Meat, poultry and fish[5]	49.9±2.7	52.1±2.9	54.0±3.3	81.0±3.5	0.035
Whole grains[6]	51.7±5.4	95.2±5.8	91.6±6.6	101.9±6.8	0.037
Refined grains[7]	259±19	286±20	285±23	286±24	0.256
Dairy products[8]	265±21	302±22	390±26	442±26	0.037
Nuts[9]	8.4±0.8	9.7±0.9	9.5±1.1	10.9±1.1	0.345

[1]Nutrients and food intakes were adjusted for total energy intake; [2]Mean (SEM) for all such values; [3]Includes pears, plums, apricots, cherries, watermelons, cantaloupe, apples, peaches, grapes, kiwi, grapefruit, oranges;tangerines, pomegranates, strawberries, bananas, sweet lemons, lemons, pineapples, and dates; [4]Includes lettuce, tomatoes, cucumbers, mixed vegetables, squash, eggplants, celery, green peas, green beans, carrots, onions, cabbage, cauliflower, Brussels sprouts, green pepper, spinach, turnips, and kale; [5]Includes beef, lamb, organ meats (beef liver, kidney and heart), hamburger, canned tuna fish, other fish, and poultry; [6]Includes whole grain breads, barley bread, wheat germ, and bulgur; [7]Includes white bread, noodle, pasta, rice, toasted bread, milled bread, sweet bread, white flour, biscuits; [8]Includes milk, chocolate milk, cheese, cream cheese, and yogurt; [9]Includes peanuts, almonds, walnuts, pistachios, hazelnuts.

adjustment for BMI, with the exception of waist circumference.

Legume intake was negatively associated with MetS (Figure 2), its prevalence being lower in the highest quartile (16.7) when compared with the lowest quartile (46.7) of legume intake ($P < 0.01$). After adjustments for life style and fruit and dairy products, subjects in the highest quartile of legume intake had lower odds of having MetS, compared with those in the lowest quartile. This association remained significant after adjustments for total fiber and magnesium; further adjustment for BMI weakened this association but it remained significant.

Discussion

The current study showed an inverse association between legume intake and MetS, fasting blood glucose, and systolic blood pressure. A positive association with HDL levels and MetS was noted. This association was independent of the consumption of other food groups such as whole grains, dairy products, and fruits and vegetables in which the beneficial effects on MetS have been shown.[4–6] To date, few observational studies have examined the association of legume intake with MetS.[12] However, previous studies investigating legume intake in the framework of dietary patterns have shown that the Mediterranean dietary pattern,[13] or dietary patterns that include increased legume intake[14] reduced the risk of MetS. It should be noted that most likely overall diet quality may protect against MetS. In a cross-sectional study, Noel et al. have reported increased risk of MetS with the traditional rice and legume pattern, possibly due to the high fat and refined rice intake in this dietary pattern.[23]

In the current study, the beneficial effects of legume intake on MetS are consistent with results of previous studies that document the protective effect of legume intake against diabetes[9] and CVD;[10] however the pathophysiologic mechanisms underlying these beneficial effects of legume intake are not fully understood, although the fiber and magnesium contents of legumes may explain these associations to some extent. To explore the potential mechanisms in the current study, we have adjusted our analysis for total fiber and dietary magnesium intakes. After this adjustment, the associations between legume intake and MetS weakened, which indicated that magnesium and total fiber were the components of legumes that could reduce the risk of MetS. However after adjustments for these nutrients, this association remained significant. Therefore in addition to these beneficial components, other components in legumes such as polyphenol may be associated with MetS; however we could not obtain data for dietary polyphenols such as flavonoids. Legumes are also an important source of vitamin B-6; the adjustment for vitamin B-6 did not alter the association of the intake of legumes and the risk of MetS. This may be a result of the low bioavailability of vitamin B-6 content of legumes. More studies are required to clarify the components by which legume intake affects inflammation and MetS.

The findings of the present study are consistent with results of prospective studies that have shown an inverse association between glucose concentration (after an oral-glucose tolerance test) and dietary legume intake independent of carbohydrate intake and BMI.[24,25] Also, long-term experimental studies have shown that inclusion of legumes in the diets of patients with obesity or cardiovascular disease resulted in improved glucose disposal.[26,27] In contrast, other experiments failed to show any beneficial effects of legumes or chickpeas on plasma glucose in healthy or hypercholesterolemic subjects with an intervention of less than six weeks duration. The authors have explained that the choice of subjects with no apparent insulin sensitivity may have resulted in lack of an association between legume intake and hyperglycemia.[28,29] However Jang et al. have shown a significant reduction of fasting glucose in non-diabetic CVD patients, compared with diabetic CVD patients, after 16 weeks of replacing whole grain/legume powder with refined rice.[26] It seems that the low statistical power resulting from short durations of studies may result in a non-significant association between legume intake and glucose and insulin concentrations.

In the current study, HDL cholesterol was higher in the highest

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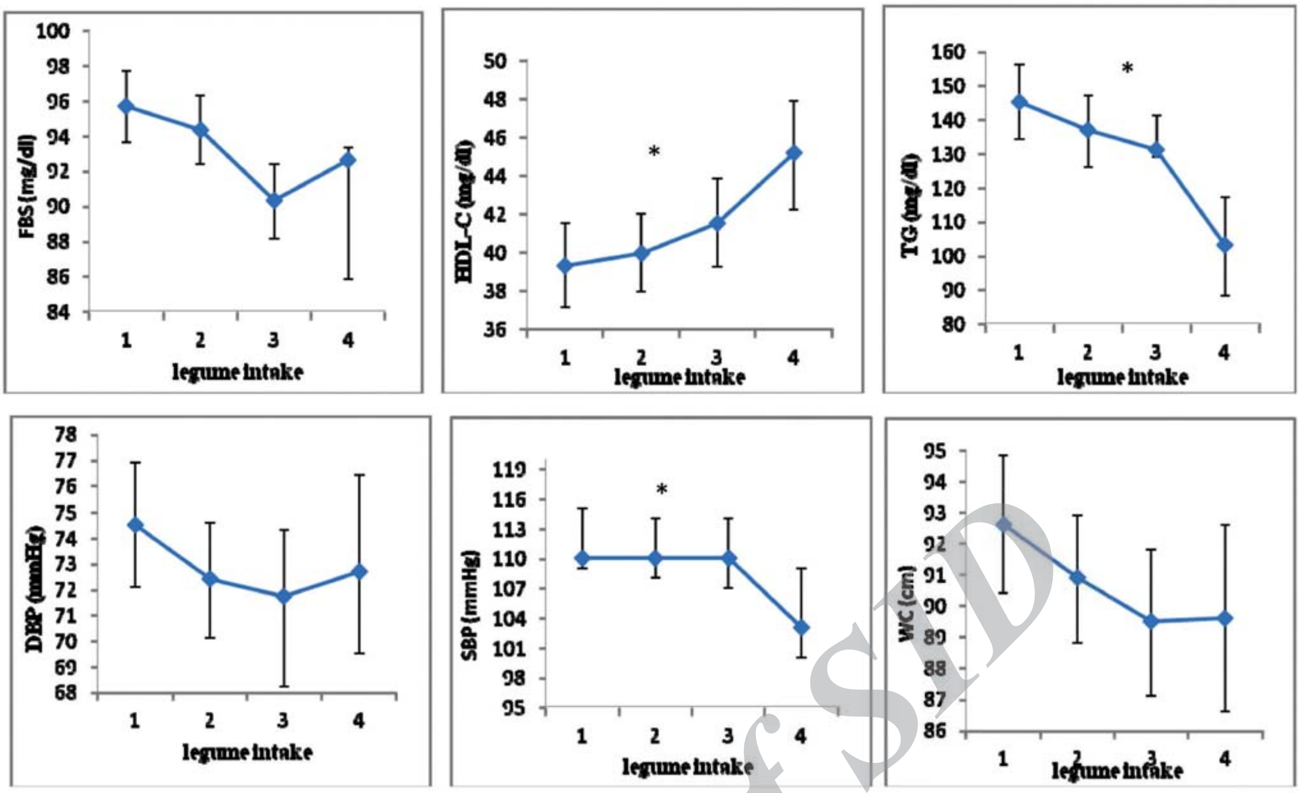

Figure 1. Adjusted means and 95% CI for components of metabolic syndrome (MetS) according to quartiles of legume consumption. * $P<0.05$ values are adjusted for physical activity, smoking status, education levels, fruits, dairy products, total fiber, magnesium and BMI. Quartile of legume intake (servings/wk) are: first quartile: ≤ 1.0, second quartile: 1.1–1.7, third quartile: 1.8–2.9, and fourth quartile: ≥ 3.0.

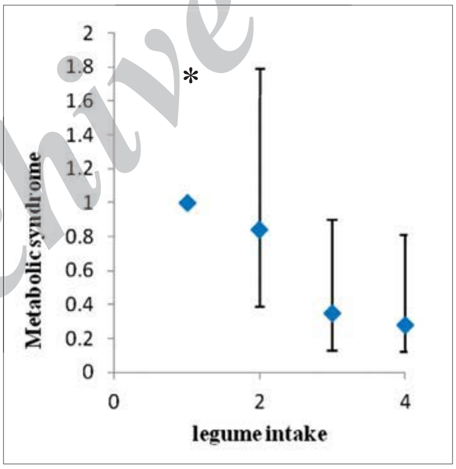

Figure 2. Multivariate adjusted odds ratio (OR) and 95% CI of metabolic syndrome (MetS) according to quartiles of legume consumption. *$P<0.05$ values are adjusted for physical activity, smoking status, education levels, fruits, dairy products, total fiber, magnesium and BMI. Quartiles of legume intake (servings/wk) are: first quartile: ≤ 1.0, second quartile: 1.1–1.7, third quartile: 1.8–2.9, and fourth quartile: ≥ 3.0.

quartile of dietary legume intake. Data on the effect of legumes on HDL cholesterol concentrations have been less consistent;[27,30,31] a meta-analysis of ten randomized control trial studies, in which the majority of participants were middle-aged men of whom many were hypercholesterolemic, showed that diets rich in non-soy legumes did not change HDL cholesterol concentrations.[32] In support of results of some interventional studies it has been shown that inclusion of legumes in the diet did not affect[31,33] or lower HDL cholesterol concentrations[27,34]. In contrast, other studies have reported that legume consumption increased HDL cholesterol concentrations.[30,35] The interpretation of these findings is complicated because of the modification of lipid profile response to dietary treatment by genetic factors,[30] and the difference in the study populations.

In this study, legume intake was inversely associated with blood pressure after adjustments for confounders. In support of our study, observational and experimental studies have shown that legume intake reduced blood pressure; in a cross-sectional study the con-

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sumption of ≤ 2 serving/wk of legumes was associated with a fourfold higher risk of hypertension compared to the consumption of ≥ 5 serving/wk of legumes.[36] The Italian National Research Council Study reported that the daily consumption of legumes has a stronger association with lower systolic blood pressure than infrequent consumption; however the differences were not significant because of limited statistical power.[37] In contrast, the Coronary Artery Risk Development in Young Adults Study reported that legume intake was not associated with a 15-year cumulative incidence of elevated blood pressure in adults;[38] a finding which could have been due to the limited consumption of legumes. Decreased blood pressure associated with legume intakes may, in part, to be attributed to the high content of both protein and soluble fiber of legumes. A meta-analysis on 24 randomized controlled studies showed that soluble fiber decreased systolic blood pressure by -1.32 and diastolic by -0.82, an effect that was stronger than that of insoluble fiber.[39] Observational studies have also reported that compared to animal protein, plant protein has a stronger inverse association with blood pressure,[40] although results were inconsistent.[41]

Previous studies have reported that legume intake, as a low glycemic index food, beneficially effects weight loss[27,42] via satiety signals such as cholecystokinin (CCK) and glucagon-like peptide-1 (GLP-1) to the satiety center in the hypothalamus, which causes a subsequent reduction in food intake.[43] The current study showed an inverse association between legume intake and enlarged waist circumference, an association which disappeared after adjustment for BMI. This was not surprising because of the strong correlation between these two variables. The low glycemic index of legumes may have an important role via the mechanisms mentioned.[44]

High intakes of legume in the present study facilitated the assessment of the relationship between legume intake and MetS. Nevertheless, this study does have its limitations. Given the case-control design, we could not determine causality between legume intake and MetS. Conclusions from dietary observational studies are always relatively difficult because of the potential for confounding factors such as other food groups. In this study, simultaneous adjustment for food groups has decreased the likelihood that the associations between legume intake and MetS were due to other food groups. However future studies that use longitudinal data are needed to clarify the effects of legumes with MetS. Since this study has included only adults, our findings cannot be extrapolated to older or younger populations.

In conclusion, this study suggests that legume intake is inversely associated with MetS, a finding that needs to be confirmed by further prospective studies.

References

1. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome. An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation*. 2005; **112:** 2735 – 2752.
2. Vimaleswaran KS, Radha V, Mohan V. Thr54 allele carriers of the Ala54Thr variant of FABP2 gene have associations with metabolic syndrome and hypertriglyceridemia in urban South Indians. *Metabolism*. 2006; **55:** 1222 – 1226.
3. Mohan V, Gokulakrishnan K, Deepa R, Shanthirani CS, Datta M. Association of physical inactivity with components of metabolic syndrome and coronary artery disease--the Chennai Urban Population Study (CUPS no. 15). *Diabet Med*. 2005; **22:** 1206 – 1211.
4. Esmaillzadeh A, Mirmiran P, Azizi F. Whole-grain consumption and the metabolic syndrome: a favorable association in Tehranian adults. *Eur J Clin Nutr*. 2005; **59:** 353 – 362.
5. Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi F. Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. *Am J Clin Nutr*. 2005; **82:** 523 – 530.
6. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Fruit and vegetable intakes, C-reactive protein, and the metabolic syndrome. *Am J Clin Nutr*. 2006; **84:** 1489 – 1497.
7. Esmaillzadeh A, Azadbakht L. Consumption of hydrogenated versus nonhydrogenated vegetable oils and risk of insulin resistance and the metabolic syndrome among Iranian adult women. *Diabetes Care*. 2008; 31: 223 – 226.
8. Azadbakht L, Esmaillzadeh A. Red meat intake is associated with metabolic syndrome and the plasma C-reactive protein concentration in women. *J Nutr*. 2009; **139:** 335 – 339.
9. Villegas R, Gao YT, Yang G, Li HL, Elasy TA, Zheng W, et al. Legume and soy food intake and the incidence of type 2 diabetes in the Shanghai Women's Health Study. *Am J Clin Nutr*. 2008; **87:** 162 – 167.
10. Nöthlings U, Schulze MB, Weikert C, Boeing H, van der Schouw YT, Bamia C, et al. Intake of vegetables, legumes, and fruit, and risk for all-cause, cardiovascular, and cancer mortality in a European diabetic population. *J Nutr*. 2008; **138:** 775 – 781.
11. Aune D, De Stefani E, Ronco A, Boffetta P, Deneo-Pellegrini H, Acosta G, et al. Legume intake and the risk of cancer: a multisite case-control study in Uruguay. *Cancer Causes Control*. 2009; **20:** 1605 – 1615.
12. Babio N, Bulló M, Basora J, Martínez-González MA, Fernández-Ballart J, Márquez-Sandoval F, et al. Adherence to the Mediterranean diet and risk of metabolic syndrome and its components. Nutr Metab Cardiovasc Dis 2009; 19: 563-70, doi:10.1016/j.numecd.2008.10.007.
13. Panagiotakos DB, Pitsavos C, Chrysohoou C, Skoumas J, Tousoulis D, Toutouza M, et al. Impact of lifestyle habits on the prevalence of the metabolic syndrome among Greek adults from the ATTICA study. *Am Heart J*. 2004; **147:** 106 – 112.
14. Deshmukh-Taskar PR, O'Neil CE, Nicklas TA, Yang SJ, Liu Y, Gustat J, et al. Dietary patterns associated with metabolic syndrome, sociodemographic and lifestyle factors in young adults: the Bogalusa Heart Study. *Public Health Nutr*. 2009; **12:** 2493 – 2503.
15. Delavari A, Forouzanfar MH, Alikhani S, Sharifian A, Kelishadi R. First nationwide study of the prevalence of the metabolic syndrome and optimal cutoff points of waist circumference in the Middle East: the national survey of risk factors for noncommunicable diseases of Iran. *Diabetes Care*. 2009; **32:** 1092 – 1097.
16. Esfahani FH, Asghari G, Mirmiran P, Azizi F. Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. *J Epidemiol*. 2010; **20:** 150 – 158.
17. Ghaffarpour M, Houshiar-Rad A, Kianfar H. The manual for household measures, cooking yields factors and edible portion of foods. Tehran, Iran: Keshaverzi Press, 1999: 1 – 46 (in Farsi).
18. Food Composition Table (FCT), food and nutrition information center, United States Department of Agriculture (USDA). www.nal.usda.gov/fnic/foodcomp.
19. Willett W, Stampfer M. Implictions of total energy intake for epidemiologic analyses. In: Willet W. Nutritional epidemiology. New York: Oxford University Press, 1998: 288 – 290.
20. Mirmiran P. principles of dietary planning. Tehran, Iran: endocrine research center, 2001 (in Farsi).
21. Kriska AM, Knowler WC, LaPorte RE, Drash AL, Wing RR, Blair SN, et al. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care*. 1999; **13:** 401 – 411.
22. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000; **32(suppl 9):** 498 – 504.
23. Noel SE, Newby PK, Ordovas JM, Tucker KL. A traditional rice and beans pattern is associated with metabolic syndrome in Puerto Rican older adults. *J Nutr*. 2009; **139:** 1360 – 1367.
24. Feskens EJ, Bowles CH, Kromhout D. Carbohydrate intake and body mass index in relation to the risk of glucose intolerance in an elderly population. *Am J Clin Nutr*. 1991; **54:** 136 – 140.
25. Feskens EJ, Virtanen SM, Räsänen L, Tuomilehto J, Stengård J, Pekkanen J, et al. Dietary factors determining diabetes and impaired glucose tolerance. A 20-year follow-up of the Finnish and Dutch cohorts of the Seven Countries Study. *Diabetes Care*. 1995; **18:** 1104 – 1112 [abstract].
26. Jang Y, Lee JH, Kim OY, Park HY, Lee SY. Consumption of whole grain and legume powder reduces insulin demand, lipid peroxidation,

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and plasma homocysteine concentrations in patients with coronary artery disease: randomized controlled clinical trial. *Arterioscler Thromb Vasc Biol*. 2001; **21:** 2065 – 2071.
27. Abete I, Parra D, Martinez JA. Legume-, fish-, or high-protein-based hypocaloric diets: effects on weight loss and mitochondrial oxidation in obese men. *J Med Food*. 2009; **12:** 100 – 108.
28. Nestel P, Cehun M, Chronopoulos A. Effects of long-term consumption and single meals of chickpeas on plasma glucose, insulin, and triacylglycerol concentrations. *Am J Clin Nutr*. 2004; **79:** 390 – 395.
29. Mekki N, Dubois C, Charbonnier M, Cara L, Senft M, Pauli AM, et al. Effects of lowering fat and increasing dietary fiber on fasting and postprandial plasma lipids in hypercholesterolemic subjects consuming a mixed Western diet. *Am J Clin Nutr.* 1997; **66:** 1443 – 1451.
30. Jang Y, Chae JS, Kim OY, Park HJ, Kim JY, Paik JK, et al. APOA5-1131T>C genotype effects on apolipoprotein A5 and triglyceride levels in response to dietary intervention and regular exercise (DIRE) in hypertriglyceridemic subjects. Atherosclerosis 2010; **211:** 512 – 519, doi:10.1016/j.atherosclerosis.2010.03.014.
31. Turley ML, Skeaff CM, Mann JI, Cox B. The effect of a low-fat, high-carbohydrate diet on serum high density lipoprotein cholesterol and triglyceride. *Eur J Clin Nutr.* 1998; **52:** 728 – 732.
32. Bazzano LA, Thompson AM, Tees MT, Nguyen CH, Winham DM. Non-soy legume consumption lowers cholesterol levels: A meta-analysis of randomized controlled trials. Nutr Metab Cardiovasc Dis (2009), doi:10.1016/j.numecd.2009.08.012.
33. Winham DM, Hutchins AM, Johnston CS. Pinto bean consumption reduces biomarkers for heart disease risk. *J Am Coll Nutr.* 2007; **26:** 243 – 249.
34. Anderson JW, Story L, Sieling B, Chen WJ, Petro MS, Story J. Hypocholesterolemic effects of oat-bran or bean intake for hypercholesterolemic men. *Am J Clin Nutr*. 1984; **40:** 1146 – 1155.
35. Yang Y, Zhou L, Gu Y, Zhang Y, Tang J, Li F, et al. Dietary chickpeas reverse visceral adiposity, dyslipidaemia and insulin resistance in rats induced by a chronic high-fat diet. *Br J Nutr*. 2007; **98:** 720 – 726.
36. Miller WL, Crabtree BF, Evans DK. Exploratory study of the relationship between hypertension and diet diversity among Saba Islanders. *Public Health Rep*. 1992; **107:** 426 – 432.
37. Trevisan M, Krogh V, Farinaro E, Panico S, Mancini M. Calcium-rich foods and blood pressure: findings from the Italian National Research Council Study (the Nine Communities Study). *Am J Epidemiol*. 1988; **127:** 1155 – 1163.
38. Steffen LM, Kroenke CH, Yu X, Pereira MA, Slattery ML, Van Horn L, et al. Associations of plant food, dairy product, and meat intakes with 15-y incidence of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Am J Clin Nutr*. 2005; **82:** 1169 – 1177.
39. Streppel MT, Arends LR, van 't Veer P, Grobbee DE, Geleijnse JM. Dietary fiber and blood pressure: a meta-analysis of randomized placebo-controlled trials. *Arch Intern Med*. 2005; **165:** 150 – 156.
40. Appel LJ. The effects of protein intake on blood pressure and cardiovascular disease. *Curr Opin Lipidol*. 2003; 14: 55 – 59.
41. Lee YP, Puddey IB, Hodgson JM. Protein, fibre and blood pressure: potential benefit of legumes. *Clin Exp Pharmacol Physiol*. 2008; **35:** 473 – 476.
42. Crujeiras AB, Parra D, Abete I, Martínez JA. A hypocaloric diet enriched in legumes specifically mitigates lipid peroxidation in obese subjects [abstract]. *Free Radic Res*. 2007; **41:** 498 – 506.
43. Vrolix R, van Meijl LE, Mensink RP. The metabolic syndrome in relation with the glycemic index and the glycemic load. *Physiol Behav.* 2008; **94:** 293 – 299, doi:10.1016/j.physbeh.2007.11.052.
44. Romaguera D, Angquist L, Du H, Jakobsen MU, Forouhi NG, Halkjaer J, et al. Dietary determinants of changes in waist circumference adjusted for body mass index - a proxy measure of visceral adiposity. *PLoS One*. 2010; **5:** 11588.

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