Positive Association Between Nutrient Adequacy and Component of Metabolic Syndrome: Outcome of a Cross-sectional Study

Aliyu Tijani Jibril
Tehran University of Medical Sciences https://orcid.org/0000-0003-3930-9091
Parivash Ghorbaninejad
Tehran University of Medical Sciences
Fatemeh Sheikhhossein
Tehran University of Medical Sciences
Sakineh Shab-Bidar (s_shabbidar@tums.ac.ir)
Tehran University of Medical Sciences

Research note

Keywords: Metabolic syndrome (MetS), Micronutrients, MetS components, nutrient adequacy

Posted Date: March 19th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-322304/v1

Abstract

Objective

Metabolic syndrome (MetS) is a multifactorial disease and its exact causes are not completely clear. Micronutrients such as vitamin A, vitamin D, zinc, and magnesium have been reported to play a role in the improvement of MetS components. We therefore aimed to investigate the association of nutrient adequacy with MetS components.

Results

Of the 850 study subjects, the mean BMI and waist circumference were 27.87 kg/m^2 and 92.08 cm respectively, with prevalence of metabolic syndrome at 12.12%. Compared with the least quartile, participants in the highest quartile had a significantly higher scores for general (p=0004) and abdominal (p=0.003) obesity. Overall adequacy of nutrients significantly increased across the quartiles. Energy and all nutrient intakes except for dietary fiber, vitamin B3, and iron were observed to significantly differ among the study groups. In this study, we observed no association between nutrient adequacy and the overall measure of MetS. However, we found a significant positive correlation between the nutrient adequacy and waist circumference, even after all potential covariates were controlled for (p<0.001).

Introduction

Metabolic syndrome (MetS) refers to a bunching of some disorders such as central obesity, elevated blood pressure, abnormal homeostasis of glucose, and 2 types of dyslipidemia, high serum TG levels and low concentration of HDL-cholesterol (HDLC) concentrations, according to the National Cholesterol Education Program Adult Treatment Panel III criteria(1, 2). Evidences show MetS to be related with increased risks of type 2 diabetes (3), cardiovascular disease (4), and all-cause mortality among adults (5). In Asia, the prevalence of MetS has been reported to be between 10-20% (5) and an 8-35% prevalence has been reported in Iran (6).

Several modifiable risk factors, such as undesirable lifestyles and poor dietary patterns have been attributed to this condition (7). Thus, dietary intakes that involve healthy food items and which cause adequate nutrient intake are useful in the progression of MetS (8).

Looking for a dietary pattern that satisfies the nutritional requirements of a population is a necessity to provide nutritional recommendations(9). The criteria that are mainly used to clarify adequacy of intake are: to prevent the deficiency associated diseases, the prevention of chronic disorders or the decrease of risk for diet-related diseases, subclinical nutritional health conditions identified by specific biochemical or functional tests, or requirements to keep body physiologically balanced (10). Therefore, nutritional adequacy (NA), referred to as the sufficient consumption of essential nutrients, needed to fulfill nutritional requirements to maximize health could be a good marker to assess subjects' nutritional status and health.

Evidence on the effect of nutritional adequacy on MetS is rare. Therefore, the present study aimed to investigate the association on nutrient adequacy with the risk of MetS in a large sample of Iranian adult participants.

Methods

Study design and participants

The present cross-sectional study was carried out among Iranian adults, aged between 18 – 59 years, referred to five different Health centers in Tehran region. These centers were selected by chance, and the same number of subjects were randomly chosen from each center. Inclusion criteria were; age between 18-75 years and willing to participate in the study. The exclusion criteria were; suffering from kidney, liver, and lung diseases, and other disorders that negatively affected the cardiovascular or respiratory system health, or infectious and active inflammatory diseases, pregnancy, lactation, routine use of supplements or drugs, like weight loss, sedative drugs, thermogenic supplements such as caffeine and green tea, etc. The study guidelines were approved by the ethical committee of Tehran University of Medical Sciences and under the Declaration of Helsinki. After informing subjects in detail about the study aims, they signed written informed consent before the start of the study.

Demographic data

A demographic questionnaire was used to collect data on age, gender, education level (illiterate, under diploma, diploma, bachelor degree and above), marital status (single, divorced, married), smoking (employed, housekeeper, retired, unemployed), and occupation (never smoked, quit smoking, low smoking, heavy smoking).

Physical activity

A validated International Physical Activity Questionnaire (IPAQ) was utilized to evaluate the physical activity levels of participants. Obtained amounts were considered based on Metabolic Equivalents (METs) and sorted into three classes (low: <600, moderate: 600 to <1500, and high ≥1500 MET-minute/week) (11).

Anthropometric and blood pressure assessment

Weight was measured with light apparel and without shoes utilizing a digital scale (808Seca, Germany) to the closest of 0.1 kg and the height was assessed while standing and keeping the shoulders and hips against the wall without shoes, using a stadiometer (Seca, Germany) with an exactness of 0.1cm. Body mass index (BMI) was calculated as weight divided by squared height and presented as kg/m^2. Waist circumference (WC) was measured between the lower rib and iliac crest, using a tape meter, according to standard guidelines. Waist to hip ratio (WHR) was determined as waist circumference (cm) divided by hip circumference (cm).

After enough rest (at least 10-15 minutes), blood pressure was acquired by a digital barometer (BC 08, Beurer, Germany) in a sitting position, and the mean of two estimations recorded for each person.

Biochemical assessments

Initial, a 10 mL venous blood sample was gotten from each subject following 7-10 hours of fasting, at that point centrifuged for 20 minutes. Fasting blood glucose (FBG) was measured using a commercial kit (Pars Azmoon, Tehran) by enzymatic colorimetric test (glucose oxidase). High-density lipoprotein (HDL-C) was assessed by the cholesterol oxidase phenol-amino-pyrine technique, and triglyceride was measured by the enzymatic method of glycerol-3-phosphate oxidase phenol-amino-pyrene with automatic apparatus (Selecta E, Vitalab, Netherland).

Dietary assessment and calculation of nutrient adequacy

Usual dietary intake was estimated using a valid and reliable 168-item Food Frequency Questionnaire (FFQ) (12) which involves a list of groceries and a standard size of each food item and was asked by trained dietitians via face-to-face interviews. Converting of consumed food portion sizes to grams was done by household measures (13) and calculated using an adjusted version of NUTRITIONIST IV software for Iranian foods (version 7.0; N-Squared Computing, Salem, OR, USA). Nutrient adequacy ratio (NAR), which is a measure of the adequacy of nutrient by comparing an individual's daily intake of a nutrient with the recommended dietary intake (RDI) or recommended dietary allowance (RDA) for that nutrient (14) was used to calculate for the micronutrient adequacy for each individual. The mean adequacy ratio (MAR) is calculated as the average of the NAR values for the selected nutrients for a certain individual (14). The MAR was therefore derived by summing the NARs and dividing by the number of micronutrients assessed. A total of 10 vitamins (A, B1, B2, B3, B6, B9, B12, C, D, and E) and 6 minerals (calcium, iron, magnesium, phosphorus, selenium, and zinc) were involved in this study.

MetS definition

The presence of at least 3 of the accompanying criteria was considered as MetS: (1) central obesity (WC≥102 cm for men and ≥88cm for women); (2) low concentrations of HDL-C (<50 mg/dL for women and <40 mg/dL for men); (3) high serum TG levels (≥150 mg/dL); (4) abnormal homeostasis of glucose (FBG > 100 mg/dL); and (5) increased blood pressure (systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥85 mm Hg)(15).

Data analysis

All statistical analyses were done using the Statistical Package for the Social Sciences (SPSS version 25; SPSS Inc.). We considered p<0.05 as the significance level. The normality test was performed by the Kolmogorov-Smirnov test and also the Q-Q plot. We analyzed the study participants' characteristics according to nutrient adequacy quartiles, using one-way analysis of variance (ANOVA) and χ^2 tests for continuous and categorical variables, respectively. Data are shown as the mean ± SD for continuous variables and percent (%) for categorical ones. In the next step, for the modeling of relationships, a linear regression test was conducted to assess the association of metabolic syndrome components with energy-adjusted nutrient adequacy after controlling for confounders such as age, sex, total physical activity, smoking habits, educational level, BMI, marital status, and occupation. Odds ratio and 95% confidence intervals were obtained using logistic regression to determine the relationship of the energy-adjusted nutrient adequacy with MetS. The risk was reported in crude and 2 adjusted models. In this analysis, the first quartile of exposure was considered as the reference category.

Results

The general characteristics of the participants across quartiles of energy-adjusted nutrient adequacy are shown in **Table 1**. A total of 850 subjects participated in this study of which 266 (31.3%) were males. The mean age of participants was 44.74 ± 10.75 years old. The mean BMI in the highest quartile was significantly higher than that of the least quartile (28.30 ± 5.58 kg/m^2 to 26.81 ± 4.30 kg/m^2, p=0.01). More participants in the highest quartile were obese in terms of general obesity (p=0004) and abdominal obesity (p=0.003) compared with subjects in the least quartile.

Table 2 contains the dietary intake of the study subjects across quartiles of energy-adjusted nutrient adequacy. The mean micronutrient adequacy ratio (MAR) scores and total energy intake significantly increased across the groups, p < 0.001. Also, we observed the mean intakes of carbohydrate, protein, total fat, monounsaturated fatty acid, and polyunsaturated fatty acid in the first quartile to be significantly lower compared to the fourth quartile intakes. Furthermore, significant differences were seen across the groups for the intakes of all the micronutrients under study except for vitamin B3 (p=0.14) and iron (p=42).

Linear regression analysis between metabolic syndrome (MetS) components and energy-adjusted nutrient adequacy is shown in **Table 3**. In the crude model, we found a significant positive correlation between WC and nutrient adequacy (β=0.10, 95% CI=3.78-16.00, p=0.002). After controlling for age and sex, a significant positive association was observed (β=0.13, 95% CI=6.93-17.91, p<0.001). Even after additional control for physical activity, smoking status, educational level, marital status, and occupation, the positive association remained significant (β=0.13, 95% CI=6.84-17.70, p<0.001). No further association was found between nutrient adequacy and other components of MetS in this population.

Discussion

To our knowledge, this was the first study to investigate the association between nutrient adequacy and odds of having MetS among the Iranian population. Of the 850 study subjects, the mean BMI and WC were 27.87 kg/m^2 and 92.08 cm respectively, with prevalence of metabolic syndrome at 12.12%. Compared with the least quartile, participants in the highest quartile had a significantly higher scores for general and abdominal obesity. Overall adequacy of nutrients significantly increased across the quartiles. Energy and all nutrient intakes except for dietary fiber, vitamin B3, and iron were observed to significantly differ among the study groups. In this study, we observed no association between NA and the overall measure of MetS. However, we found a significant positive correlation between the NA and WC, even after all potential covariates were controlled for.

While some studies have found significant association between micronutrient intakes with MetS or its components (16-18), others have reported no association (19-21).

In contrast to our result, a finding from an observational study indicated that a twofold increase in total vitamin A and C intake in women decreases the odds of having MetS and its component except for WC (22). Another finding from a clinical trial showed that sufficient intake of vitamin D was associated with a reduced WC, MetS, and fasting blood glucose (FBG) (16). Moreover, a recently published cross-sectional study revealed that vitamin B6 and B12 were inversely linked with MetS in adult and children, respectively (18).

Overall diets rather than individual nutrients or food groups have a greater influence on health than individual micronutrients (23). Thus, dietary patterns may be more effective in demonstrating associations with body composition (24) and the development of chronic and degenerative diseases (19, 25-29). A “healthy dietary pattern” has been found to be independently associated with a higher micronutrient adequacy (30-32), while an “unhealthy dietary pattern” has been linked with decreased nutrient densities of vitamin A, C, D, E, K and folate and calcium (30). In a cross-sectional study of Greek adults, Panagiotakos et al., found that the healthful dietary pattern, similar to MedDiet, which is loaded with vitamins such as B1, B2, niacin, B6, folates, or B12 and antioxidant vitamins (vitamins E and C) was inversely associated with waist circumference, blood pressure, and triglycerides, and positively associated with HDL-cholesterol levels, all known components of MetS (33). Furthermore, it has been shown that adherence to a diet loaded with antioxidants resulted in a lower level of HDL concentrations (17).

This discrepancy might be explained by a lack of control for several confounders in some studies. In addition, different components of dietary patterns across studies along with differences in dietary assessment tools might explain these inconsistent findings.

Conclusion

In conclusion, our findings indicated a positive association between nutrient adequacy and odds of having greater WC among Iranian adults. Further, prospective studies are required to confirm our findings.

Limitations

The major limitation of this study was that, because the exposure and outcome were simultaneously assessed, there is generally no evidence of a temporal relationship between the exposure and outcome.

List Of Abbreviations

AI adequate intake

AR average requirement

BMI body mass index

DRI dietary reference intake

FBG fasting blood glucose

FFQ food frequency questionnaire

HDL high-density lipoprotein

IPAQ international physical activity questionnaire

MAR mean adequacy ration

NAR nutrient adequacy ration

MetS metabolic syndrome

METs metabolic equivalents

NA nutrient adequacy

RDA recommended dietary allowance

TG triglyceride

WC waist circumference

WHR waist-to-hip ratio

Declarations

Ethical Approval and Consent to Participate

The study guidelines were approved by the ethical committee of Tehran University of Medical Sciences and under the Declaration of Helsinki. After informing subjects in detail about the study aim, they signed written informed consent before the start of the study.

Consent for Publication

Not applicable

Availability of Data and Materials

The dataset analyzed during the current study is available from the corresponding author on reasonable request.

Competing Interest

All authors declared that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contribution

ATJ and SS-b contributed to conception/design of the research; ATJ and SS-b contributed to acquisition, analysis, and interpretation of the data; ATJ, PG, and FS drafted the manuscript; SS-b critically revised the manuscript; and SS-b agrees to be fully accountable for ensuring the integrity and accuracy of the work. All authors read and approved the final manuscript.

Acknowledgements:

We acknowledge all subjects who consented to taking part in this study.

References

1. Meigs JB. Epidemiology of the metabolic syndrome, 2002. The American journal of managed care. 2002;8(11 Suppl):S283-92; quiz S93-6.
2. 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(17):2735-52.
3. Haffner SM, Valdez RA, Hazuda HP, Mitchell BD, Morales PA, Stern MP. Prospective analysis of the insulin-resistance syndrome (syndrome X). Diabetes. 1992;41(6):715-22.
4. Isomaa B, Almgren P, Tuomi T, Forsén B, Lahti K, Nissén M, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes care. 2001;24(4):683-9.

5. Hu G, Qiao Q, Tuomilehto J, Balkau B, Borch-Johnsen K, Pyorala K. Prevalence of the metabolic syndrome and its relation to all-cause and cardiovascular mortality in nondiabetic European men and women. Archives of internal medicine. 2004;164(10):1066-76.
6. Azizi F, Salehi P, Etemadi A, Zahedi-Asl S. Prevalence of metabolic syndrome in an urban population: Tehran Lipid and Glucose Study. Diabetes research and clinical practice. 2003;61(1):29-37.
7. de la Iglesia R, Loria-Kohen V, Zulet MA, Martinez JA, Reglero G, Ramirez de Molina A. Dietary Strategies Implicated in the Prevention and Treatment of Metabolic Syndrome. International journal of molecular sciences. 2016;17(11).
8. Calton EK, James AP, Pannu PK, Soares MJ. Certain dietary patterns are beneficial for the metabolic syndrome: reviewing the evidence. Nutrition research (New York, NY). 2014;34(7):559-68.
9. Román-Viñas B, Serra-Majem L, Ribas-Barba L, Ngo J, García-Alvarez A, Wijnhoven TM, et al. Overview of methods used to evaluate the adequacy of nutrient intakes for individuals and populations. The British journal of nutrition. 2009;101 Suppl 2:S6-11.
10. Dhonukshe-Rutten RA, Bouwman J, Brown KA, Cavelaars AE, Collings R, Grammatikaki E, et al. EURRECA-Evidence-based methodology for deriving micronutrient recommendations. Critical reviews in food science and nutrition. 2013;53(10):999-1040.
11. Wareham NJ, Jakes RW, Rennie KL, Schuit J, Mitchell J, Hennings S, et al. Validity and repeatability of a simple index derived from the short physical activity questionnaire used in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Public Health Nutr. 2003;6(4):407-13.
12. Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. Public Health Nutr. 2010;13(5):654-62.
13. Ghafarpour M, Houshiar-Rad A, Kianfar H, Ghaffarpour M. The manual for household measures, cooking yields factors and edible portion of food. 1999.
14. Castro-Quezada I, Román-Viñas B, Serra-Majem LJN. The Mediterranean diet and nutritional adequacy: a review. 2014;6(1):231-48.
15. Expert Panel on Detection E. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). Jama. 2001;285(19):2486.
16. Verrusio W, Andreozzi P, Renzi A, Musumeci M, Gueli N, Cacciafesta M. Association between serum vitamin D and metabolic syndrome in middle-aged and older adults and role of supplementation therapy with vitamin D. Ann Ist Super Sanita. 2017;53(1):54-9.
17. Shahinfar H, Akbarzade Z, Djafari F, Shab-Bidar S. Association of nutrient patterns and metabolic syndrome and its components in adults living in Tehran, Iran. Journal of Diabetes & Metabolic Disorders. 2020.
18. Villatoro Santos CR. Micronutrients and Metabolic Syndrome in Children and Adults 2019.
19. Motamed S, Ebrahimi M, Safarian M, Ghayour-M, Mouhebati M, Azarpazhouh M, et al. Micronutrient intake and the presence of the metabolic syndrome. North American journal of medical sciences. 2013;5(6):377.
20. Morton JP, Iqbal Z, Drust B, Burgess D, Close GL, Brukner PDJAP, Nutrition,, et al. Seasonal variation in vitamin D status in professional soccer players of the English Premier League. 2012;37(4):798-802.
21. Willis KS, Smith DT, Broughton KS, Larson-Meyer DEJOajosm. Vitamin D status and biomarkers of inflammation in runners. 2012;3:35.

22. Park S, Ham J-O, Lee B-K. Effects of total vitamin A, vitamin C, and fruit intake on risk for metabolic syndrome in Korean women and men. Nutrition. 2015;31(1):111-8.
23. Jayasinghe SN, Breier BH, McNaughton SA, Russell AP, Della Gatta PA, Mason S, et al. Dietary Patterns in New Zealand Women: Evaluating Differences in Body Composition and Metabolic Biomarkers. 2019;11(7):1643.
24. Schrijvers JK, McNaughton SA, Beck KL, Kruger RJN. Exploring the dietary patterns of young New Zealand women and associations with BMI and body fat. 2016;8(8):450.
25. Zheng T, Boyle P, Willett WC, Hu H, Dan J, Evstifeeva TV, et al. A case-control study of oral cancer in Beijing, People's Republic of China. Associations with nutrient intakes, foods and food groups. Eur J Cancer B Oral Oncol. 1993;29b(1):45-55.
26. Campdelacreu J. Parkinson disease and Alzheimer disease: environmental risk factors. Neurologia. 2014;29(9):541-9.
27. Wark PA, Lau R, Norat T, Kampman E. Magnesium intake and colorectal tumor risk: a case-control study and meta-analysis. Am J Clin Nutr. 2012;96(3):622-31.
28. Shah R. The role of nutrition and diet in Alzheimer disease: a systematic review. J Am Med Dir Assoc. 2013;14(6):398-402.
29. Rees K, Dyakova M, Ward K, Thorogood M, Brunner E. Dietary advice for reducing cardiovascular risk. Cochrane Database of Systematic Reviews. 2013(3).
30. Richter A, Heidemann C, Schulze MB, Roosen J, Thiele S, Mensink GBJBp. Dietary patterns of adolescents in Germany-associations with nutrient intake and other health related lifestyle characteristics. 2012;12(1):35.
31. Serra-Majem L, Bes-Rastrollo M, Román-Viñas B, Pfrimer K, Sánchez-Villegas A, Martínez-González MA. Dietary patterns and nutritional adequacy in a Mediterranean country. Br J Nutr. 2009;101 Suppl 2:S21-8.
32. Maillot M, Issa C, Vieux F, Lairon D, Darmon N. The shortest way to reach nutritional goals is to adopt Mediterranean food choices: evidence from computer-generated personalized diets. Am J Clin Nutr. 2011;94(4):1127-37.
33. 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(1):106-12.

Tables

Table 1. General characteristics of participants across quartiles of energy-adjusted nutrient adequacy

Variables	Quartiles of nutrient adequacy				
	Q_1	Q_2	Q_3	Q_4	P-value[a]
Samples	212 (24.9%)	214 (25.2%)	212 (24.9%)	212 (24.9%)	
Q ranges	≤ 0.6861	0.6862 – 0.7792	0.7793 – 0.8525	≥ 0.8526	
Age (year)	45.74(10.54)	45.19(10.13)	44.36(11.15)	43.67(11.11)	0.20
BMI (kg/m^2)	26.81(4.30)	28.07(4.54)	28.27(7.25)	28.30(5.58)	0.01
WC (cm)	90.18(13.17)	93.08(12.12)	92.53(11.69)	92.49(12.59)	0.07
FBG (mg/dL)	107.73(57.23)	109.37(42.63)	110.04(35.17)	106.53(31.50)	0.83
TG (mg/dL)	149.16(87.46)	139.43(72.32)	147.54(77.18)	145.63(80.18)	0.60
HDL-C (mg/dL)	49.74(9.88)	50.76(10.43)	49.28(10.39)	49.76(10.12)	0.49
SBP (mm Hg)	119.03(26.19)	120.49(22.60)	119.40(19.89)	119.92(20.22)	0.91
DBP (mm Hg)	78.80(15.09)	78.47(15.13)	78.17(12.94)	78.00(12.07)	0.93
Gender (men) (%)	80 (30.1)	74 (27.8)	65 (24.4)	47 (17.7)	0.004
Education (university graduate) (%)	62 (21.2)	80 (27.4)	75 (25.7)	75 (25.7)	0.30
Occupation (employed) (%)	55 (25.0)	57 (25.9)	44 (20.0)	64 (29.1)	0.15
Marital status (married) (%)	169 (24.6)	172 (25.0)	173 (25.1)	174 (25.3)	0.96
Smoking status (current smoker) (%)	13 (29.5)	11 (25.0)	10 (22.7)	10 (22.7)	0.97
Physically active (moderate) (%)	75 (24.2)	78 (25.2)	80 (25.8)	77 (24.8)	0.77
General obesity[b] (%)	40 (16.7)	62 (25.8)	68 (28.3)	70 (29.2)	0.004
Abdominal obesity[c] (%)	80 (19.3)	114 (27.5)	107 (25.8)	113 (27.3)	0.003
Metabolic syndrome[d] (%)	22 (21.4)	31 (30.1)	28 (27.2)	22 (21.4)	0.46

BMI, body mass index; kg/m^2, kilogram/meter^2; WC, waist circumference; cm, centimeter; FBG, fasting blood glucose; mg/dL, milligram/deciliter; TG, triglyceride; HDL-C, high-density lipoprotein-cholesterol; SBP, systolic blood pressure; mm Hg, millimeters of mercury; DBP, diastolic blood pressure.

Data are presented as mean ± standard deviation (SD) or percent.

[a]Calculated by Chi-square and analysis of variance for qualitative and quantitative variables, respectively and p-value<0.05 indicates significant level.

[b]General obesity is considered as BMI ≥ 30 kg/m^2.

[c]Abdominal obesity is considered as WC ≥ 88 cm for women and ≥ 102 cm for men.

[d]Hypertriglyceridemia, Hypertension, Hyperglycemia, Low-High Density Lipoprotein cholesterol, Enlarged waist circumference

Table 2. Dietary intakes of participants across quartiles of energy-adjusted nutrient adequacy

Variables	Quartiles of nutrient adequacy				
	Q_1	Q_2	Q_3	Q_4	P-value[a]
Range	≤ 0.6861	0.6862 – 0.7792	0.7793 – 0.8525	≥ 0.8526	
MAR	0.57 (0.11)	0.73 (0.02)	0.81 (0.02)	0.90 (0.04)	<0.001
Total energy (kcal/d)	1931 (922)	2472 (3347)	2501 (880)	3369 (1410)	<0.001
Total fat (g/d)	62.33 (39.99)	70.98 (31.32)	77.19 (30.72)	118.87 (71.81)	<0.001
MUFA (%)	22.56 (47.27)	21.81 (12.03)	23.28 (10.63)	35.69 (23.72)	<0.001
PUFA (%)	12.70 (7.89)	15.85 (9.42)	15.38 (7.63)	24.61 (19.12)	<0.001
Carbohydrate (g/d)	290.54(150.42)	396.28(858.36)	370.35(143.67)	481.82(220.66)	<0.001
Protein (g/d)	64.78 (34.26)	79.12 (57.32)	86.65 (30.27)	115.36 (50.09)	<0.001
Dietary fiber (g/d)	19.79 (124.89)	23.75 (123.78)	19.49 (7.37)	30.09 (14.06)	0.57
Vitamin A (µg/d)	997.73(4213.41)	1288.31(4181.84)	1511.81(981.36)	2921.29(2270.46)	<0.001
Vitamin B1 (mg/d)	0.97 (0.65)	1.53 (0.70)	1.78 (0.84)	2.38 (1.15)	<0.001
Vitamin B2 (mg/d)	0.42 (0.47)	1.01 (0.42)	1.48 (0.83)	2.57 (1.46)	<0.001
Vitamin B3 (mg/d)	19.28 (78.00)	24.54 (77.13)	22.97 (8.87)	31.48 (14.47)	0.14
Vitamin B6 (mg/d)	0.36 (0.44)	0.80 (0.52)	1.40 (0.78)	2.41 (1.32)	<0.001
Vitamin B9 (µg/d)	199.26 (283.28)	278.66 (279.23)	345.90 (122.95)	560.85 (251.68)	<0.001
Vitamin B12 (µg/d)	1.60 (0.98)	2.96 (1.81)	4.33 (5.46)	6.63 (6.39)	<0.001
Vitamin C (mg/d)	126.46 (523.83)	164.21 (519.30)	180.63 (115.38)	318.07 (222.49)	<0.001
Vitamin D (µg/d)	0.60 (0.89)	1.27 (1.30)	1.82 (1.73)	3.95 (3.74)	<0.001
Vitamin E (mg/d)	2.54 (2.47)	3.61 (2.91)	4.80 (4.36)	10.12 (10.28)	<0.001
Calcium (mg/d)	1224.28(1374.68)	1538.25(1435.53)	1679.10(1448.95)	1905.17(1339.94)	<0.001
Phosphorus (mg/d)	673.70 (378.85)	894.32 (1067.59)	1038.66 (530.64)	1759.40 (964.00)	<0.001

Magnesium (mg/d)	217.06 (131.93)	289.51 (553.11)	274.77 (113.43)	418.67 (203.13)	<0.001
Iron (mg/d)	54.63 (93.21)	70.71 (149.95)	66.33 (102.80)	57.44 (98.46)	0.42
Potassium (mg/d)	2622.55 (1419.45)	4211.42 (15243.05)	3473.37 (1150.68)	5567.81 (2938.86)	0.001
Zinc (mg/d)	7.11 (10.43)	8.23 (9.10)	9.28 (8.81)	12.79 (6.64)	<0.001

MAR, mean adequacy ratio; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.

Data are presented as mean ± standard deviation (SD).

[a]Calculated by analysis of variance and p-value<0.05 indicates significant level.

Table 3. Association of energy-adjusted nutrient adequacy with metabolic syndrome components

	Nutrient adequacy			
Variables	**β (SE)**	**95% CI**	**R^2**	**P-value[a]**
TG (mg/dL)				
Crude	0.02 (19.99)	-27.47, 51.02	<0.001	0.55
Model 1[b]	0.02 (20.07)	-27.13, 51.65	0.003	0.54
Model 2[c]	0.02 (20.22)	-24.32, 55.08	0.01	0.44
SBP (mm Hg)				
Crude	0.03 (5.62)	-5.42, 16.66	0.001	0.31
Model 1[b]	0.05 (5.22)	-2.05, 18.44	0.14	0.11
Model 2[c]	0.05 (5.19)	-2.05, 18.33	0.17	0.11
DBP (mm Hg)				
Crude	-0.01 (3.49)	-8.45, 5.24	<0.001	0.64
Model 1[b]	-0.006 (3.42)	-7.36, 6.08	0.04	0.85
Model 2[c]	-0.02 (3.34)	-9.38, 3.73	0.11	0.39
FBG (mg/dL)b				
Crude	-0.002(10.76)	-21.82, 20.42	<0.001	0.94
Model 1[b]	0.001(10.80)	-20.79, 21.61	0.002	0.97
Model 2[c]	-0.001(10.85)	-21.47, 21.13	0.01	0.98
HDL-C (mg/dL)d				
Crude	-0.04 (2.56)	-8.03, 2.05	0.002	0.24
Model 1[b]	-0.04 (2.57)	-8.18, 1.92	0.006	0.22
Model 2[c]	-0.04 (2.58)	-8.66, 1.49	0.02	0.16
WC (cm)				
Crude	0.10 (3.11)	3.78, 16.00	0.01	0.002
Model 1[b]	0.13 (2.79)	6.93, 17.91	0.21	<0.001
Model 2[c]	0.13 (2.76)	6.84, 17.70	0.23	<0.001

β, standardized coefficients; SE, standard error; CI, confidence interval; R^2, R square; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; HDL-C, high-density lipoprotein-cholesterol; WC, waist circumference.

[a]P-values are reported based on the linear regression test and are considered significant at [illegible]0.05

[b]Model 1: adjusted for age + sex

[c]Model 2: Model 1 + total physical activity + smoking habits+ educational level + BMI + marital status + occupation