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The Association Between Empirical Dietary Inflammatory Pattern and Metabolic Phenotypes in Overweight/Obese Adults

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Abstract

Objectives: The study aimed to investigate whether diet-induced inflammation assessed by Empirical Dietary Inflammatory Pattern (EDIP) is associated with odds of unhealthy metabolic phenotype and components of metabolic syndrome (MetS).
Methods: This cross-sectional study included 403 overweight/obese individuals recruited from employees of two pharmaceutical companies in Iran. The weighted intake of 15 food groups was summed to construct EDIP and metabolic phenotypes were defined based on MetS criteria.
Results: After adjusting for age, sex, BMI, and marital status, the odds of unhealthy phenotype increased significantly from quartile 1 to quartile 4 (P-trend = 0.013). However, the association became non-significant after adjusting for energy intake. Compared to those in the lowest quartile, individuals with higher EDIP scores had higher odds of high fasting blood sugar (FBS) (P-trend = 0.031) and low HDL-C (P-trend = 0.036) after adjusting for all covariates. By adding energy intake into the model, an inverse association was observed between EDIP, waist circumference (WC), and odds of high WC.
Conclusions: A higher pro-inflammatory diet was associated with higher odds of unhealthy phenotype, high FBS, and low-HDL-C in overweight/obese individuals. However, the association with unhealthy phenotype seems to be dependent on the energy intake.

Keywords: Empirical Dietary Inflammatory Pattern, Dietary Inflammatory Index, Metabolic Phenotypes, Metabolically Healthy Obesity

1. Background

Over the past three decades in parallel with rapid urbanization and economic growth, overweight and obesity have become one of the major public health concerns that attribute to the increased risk of metabolic and cardiovascular diseases (1, 2). However, 9% - 34% of obese individuals have normal cardio-metabolic profiles, who are called metabolically healthy obese (MHO) (3, 4). MHO might not be a permanent state because it can be transitioned to metabolically unhealthy (5, 6). Subclinical inflammation is one of the mechanisms that can explain the existence of cardio-metabolic disturbances concurrent obesity. Systemic inflammatory markers are higher in metabolically unhealthy obese (MUO) individuals compared to MHO people (7, 8). MUO individuals also have higher visceral adipose tissues and hepatic fat, indicating a higher local adipose tissue inflammation compared to MHO (9).

Pro- and anti-inflammatory properties of some nutritional factors show that diet can influence chronic inflammation. Therefore, inflammatory indices have been developed to assess the inflammatory potential of the diet (10, 11). A cross-sectional study using a literature-derived nutrient-based dietary inflammatory index (DII) showed positive associations of the DII with body mass index (BMI) and waist circumference (WC) (12). Studies investigating the associations between the score and risk of metabolic syndrome (MetS) have reported inconsistent findings (13-17). Two cross-sectional studies could not find any significant association between the DII and odds of MetS (13, 14). However, in another cross-sectional study, a higher DII score was associated with decreased odds of having MetS among women (17). In prospective investigations, a study conducted in Spanish population did not show any significant association between the DII and MetS (16) while a study conducted among French adults suggested a higher odds of MetS associated with higher DII scores (15). In addition to this inconsistency, the association between qualities of a diet based on inflammation with different pheno-

types of overweight/obesity has not been investigated. Empirical Dietary Inflammatory Pattern (EDIP) is a hypothesis-driven index that has been recently proposed to assess the inflammatory potential of the diet based on the intake of food groups (11). The aim of this study was to investigate the association between EDIP and odds of unhealthy phenotype among overweight/obese adults. The association of the EDIP with each MetS component and odds of metabolic disturbances was also investigated.

2. Methods

This cross-sectional study was conducted among 403 employees of two pharmaceutical companies in Iran. Volunteers could be included in this study if they were aged older than 18 years and had a BMI higher than 25 kg/m^2. Pregnant and lactating women, those with a history of chronic diseases including cancer, cardiovascular, renal, hepatic, and gastrointestinal diseases, and those taking mineral and vitamin supplements within the past 3 months were excluded. The ethics committee of Iran University of Medical Sciences approved the study protocol and a written informed consent was received from every participant.

Information on age, smoking habits, education, marital status, and medication was collected using a questionnaire. The participants were divided into two groups based on smoking habits: non-smokers and smokers (current- and ex-smokers). Education status was categorized into two groups of diploma and higher than a diploma. Marital status was considered as two groups of single and married.

Body weight (in kg) was measured to the nearest 0.1 kg while the subjects wearing light clothing without shoes and height (in cm) was measured to the nearest 0.5 cm by using a stadiometer. WC was measured at midway between the costal margin and the iliac crest to the nearest 0.5 cm using an inextensible measuring tape. Blood pressure (BP) was measured by a standardized mercury sphygmomanometer, twice on the right arm in a seated position, after 5-minute rest; the average of the two measurements was considered as participant's BP.

Dietary intake was assessed using 3-day 24-hour food recall, including 2 weekdays and one weekend day, collected in a face-to-face interview by trained dietitians. Inflammatory potential of diets was assessed by developing EDIP based on food group intakes. To develop the score, dietary intakes were assigned into the 15 food groups based on Tabung et al. study (11), including tea, coffee, dark yellow vegetables, leafy green vegetables, snacks, fruit juice, pizza, processed meat, red meat, organ meat, other fish, other vegetables, refined grains, high-energy beverages, and tomatoes. Low-energy beverages, beer, and wine were not used to construct EDIP score because drinking the beverage was not usual in our population. Mean daily intake of each food group was determined by defined serving sizes (18) and then weighted by the proposed regression coefficients. The weighted intake of food groups was summed to construct EDIP and then rescaled by dividing by 1000 to decrease the magnitude of the score and simplify the interpretation (11).

Blood samples were taken from every participant after an overnight fast of 8 - 12 hours. Fasting blood sugar (FBS), triglycerides (TGs), and high-density lipoprotein cholesterol (HDL-C) were measured by the enzymatic calorimetry method. All analyses were performed using Pars Azmun commercial kits. Inter- and intra-assay coefficients of variation (CVs) for FBS were 1.5%. Inter- and intra-assay CVs were 1.6 and 1.2 for TG and 0.9 and 1.1 for HDL-C, respectively.

Individuals who met 3 or more criteria for MetS were considered as unhealthy phenotype. The MetS criteria were based on the Harmonization definition as following (19): Abdominal obesity (WC $\geq$ 95 cm in both sexes) (20), high TGs ($\geq$ 150 mg/dL or drug treatment for high TGs), low HDL-C($<$ 40 mg/dL in men or $<$ 50 mg/dL in women or drug treatment), high BP (systolic/diastolic BP $\geq$ 130/85 or antihypertensive drug treatment, and high FBS ($\geq$ 100 mg/dL or drug treatment for elevated glucose).

Ethical Standard

The ethical approval Number is IR.IUMS.REC 1395.95-02-27-9221324206. A written informed consent was received from all participants.

Statistical Analysis

Characteristics of participants according to the metabolic phenotypes of healthy and unhealthy were compared using student's t-test for continuous variables and chi-square for categorical variables. FBS and TGs showed non-normal distribution and therefore, they were transformed logarithmically (ln) before analyses. Logistic regression was used to estimate the odds of unhealthy phenotype metabolic disturbances across quartiles of the EDIP. Odds ratios (ORs) and 95% confidence interval (95%CI) were reported for each quartile, considering the lowest quartile as the reference group. Odds of unhealthy phenotype and metabolic disturbances were also reported per 1- standard deviation (SD) changes in the EDIP, considering the EDIP as a continuous variable. The linear regression was used to examine the association between the EDIP and each component of MetS. Two models were constructed for regression analyses; model 1 was adjusted for age (years), sex, BMI (kg/m^2), and marital status (single/married), and model 2 was additionally adjusted for total energy intake (Kcal/day). The regression models were not adjusted for smoking and education because of non-significant differences between the two groups of

healthy/unhealthy and no alteration in results by adding these variables. Statistical analyses were done by using SPSS (version 20; IBM Corp).

Results

Mean ($\pm$ SD) age and BMI of the participants were 44.2 $\pm$ 8.96 years and 29.9 $\pm$ 3.61 kg/m^2, respectively, and 55.1 % were women. The mean of EDIP was 0.58 $\pm$ 0.36, with a range from -0.24 to 1.86. Of the participants, 176 individuals (43.7%) were unhealthy metabolically. The characteristics of the participants according to metabolic phenotypes are presented in Table 1. Overall, participants with unhealthy phenotype were older, less likely to be women, more likely to be single and obese, and had higher BMI, WC, BP, FBS, and TGs but lower HDL-C.

The odds of unhealthy metabolic phenotype increased gradually by increasing the EDIP score from quartile 1 to 4 in an unadjusted model (P-trend = 0.003). The odds of unhealthy phenotype were more than twice higher in individuals with quartiles 3 (OR = 2.37; 95%CI = 1.34, 4.19) and 4 (OR = 2.06; 95 CI = 1.16, 3.65) of the EDIP compared to those in the lowest quartile. After including age, sex, BMI, and marital status into the model (model 1), the association between EDIP and unhealthy phenotype remained significant (P-trend = 0.013). However, when energy intake was added to the model (model 2), the association became non-significant. When the EDIP was considered as a continuous variable, the odds of unhealthy phenotype increased by 38% (95 % CI = 1.13, 1.69) per 1-SD increase in the EDIP; the association was significant after adjusting for age, sex, BMI, and marital status but became non-significant by adding energy intake into the model (Table 2).

The associations between EDIP and the components of MetS are presented in Table 3. A two percent higher in FBS was observed per 1-SD increase in the EDIP in an unadjusted model (< 0.001) and after adjusting for age, sex, BMI, and marital status (P = 0.001). An additional adjustment for energy intake reduced the association towards non-significant (P = 0.080). One SD increase in the EDIP was associated with -1.59 mg/dL lower HDL-C concentrations (95% CI = -2.56, -0.62). After inclusion of age, sex, BMI (model 1; P = 0.003), and energy intake (model 2; P = 0.001), the association remained statistically significant. No significant association was observed between EDIP and WC in an unadjusted model and model 1 but when energy intake was included to the model, the EDIP was significantly associated with lower WC (β = -0.87 (95%CI = -1.67, -0.08). The EDIP was not associated with BP and TGs.

The associations between EDIP and odds of metabolic disturbances are presented in Table 4. Compared to those in the lowest quartile, individuals with higher EDIP scores had higher odds of high FBS (P-trend = 0.031) and low HDL (P-trend = 0.036) in a fully adjusted model (model 2). The odds of high FBS and low HDL increased significantly by 28% and 52%, respectively, per 1-SD increase in EDIP after adjusting for all covariates. After adding energy intake into model 1, the odds of high WC were significantly lower in those with the highest quartile of EDIP than those with the lowest quartile of EDIP.

4. Discussion

In the present study, a higher pro-inflammatory diet, assessed based on food group intakes, was associated with higher odds of having an unhealthy metabolic phenotype in overweight/obese adults after adjusting for age, sex, BMI, and marital status. However, the inclusion of energy intake to the model made this association non-significant, suggesting that the observed association could be dependent on energy intake. The higher EDIP was associated with a higher FBS but with lower HDL-C concentrations, and higher odds of high FBS and low HDL; the associations remained significant even after adjustment for energy intake. In addition, an inverse association was observed between EDIP and WC independent of BMI, energy intake, and demographic variables.

DII is developed to study the relationship between diet, inflammation, and inflammatory diseases with no need to measure inflammatory markers directly. A literature-derived DII has been developed by Shivappa et al. in which DII score has been calculated considering intakes of 45 food parameters (10). Based on the suggestion of the score, studies have examined the associations between the score and different inflammatory-related outcomes. Of 3 studies investigating the association between the DII and odds of MetS cross-sectionally (13, 14, 17), two reported no significant association (13, 14) and one reported an unexpected finding of inverse association among women (17). A prospective study conducted among Spanish adults also could not find any significant association between the DII and development of MetS after a median of 8.3 years (16). However, Neufcourt et al. showed that the odds of occurrence of MetS were higher in individuals in quartile 4 compared to those in quartile 1 (OR = 1.39, 95% CI = 1.01 - 1.92; P = 0.047) after 13 years of follow-up in middle-aged French adults (15). Although all the above-mentioned studies used the literature-derived DII, the number of food parameters to assess DII score varied across the study.

In this study, the inflammatory potential of diets was assessed based on the calculation of EDIP scores, a hypothesis-derived empirical index that has been recently proposed by Tabung et al. Creating this inflammation-related dietary pattern indicates inflammatory effects of foods in whole diets. In addition, developing the inflammatory index based on food groups facilitate providing nu-

Table 1. Characteristics of Participants According to Metabolic Phenotypes[a]

Characteristics	Overweight-Obese Metabolic Phenotypes		P Values
	Healthy (n = 227)	Unhealthy (n = 176)	
Age, y	43.1 ± 8.73	45.6 ± 9.09	0.006
Women	138 (60.8)	84 (47.7)	0.012
Smoker	51 (22.5)	32 (18.2)	0.322
Education (< 12 years)	128 (56.4)	94 (53.4)	0.614
Marital status (single)	13 (5.7)	20 (11.4)	0.045
BMI, kg/m^2	29.1± 3.06	30.9± 4.00	< 0.001
BMI ≥ 30 kg/m^2	77 (33.9)	86 (48.9)	0.003
WC, cm	90.7 ± 9.86	98.51 ± 9.78	< 0.001
SBP, mmHg	11.5 ± 1.44	12.4 ± 1.81	< 0.001
DBP, mmHg	7.54 ± 1.11	8.36 ± 1.16	< 0.001
FBS[b], mg/dL	93.6 ± 8.23	105.9 ±16.55	< 0.001
HDL, mg/dL	50.2 ± 9.47	44.7 ± 9.90	< 0.001
TGs[b], mg/dL	128.7 ± 52.4	179.0 ± 66.9	< 0.001
Drug consumption			0.005
BS lowering	1 (0.4)	1 (0.6)	
Lipid Lowering	7 (3.1)	19 (10.8)	
BP lowering	7 (3.1)	11 (6.2)	
Metabolic disturbances			
High WC	62 (27.3)	113 (64.2)	< 0.001
High BP	69 (30.4)	131 (74.4)	< 0.001
High FBS	32 (14.1)	121 (68.8)	< 0.001
High TGs	45 (19.8)	135 (76.6)	< 0.001
Low HDL	88 (38.8)	112 (63.6)	< 0.001

Abbreviations: DBP, diastolic blood pressure; FBS, Fasting blood sugar; High BP, systolic/diastolic BP ≥ 130/85 mmHg or antihypertensive drug treatment; High FBS, ≥ 100 mg/dL or drug treatment for elevated glucose; High TGs, ≥ 150 mg/dL or drug treatment for hyperlipidemia; High WC, WC ≥ 95 cm; Low HDL, < 40 mg/dL in men, < 50 mg/dL in women or drug treatment for hyperlipidemia; SBP, systolic blood pressure; TGs, Triglycerides; WC, waist circumference.
[a] Data are presented as mean ± SDs or No. (%).
[b] ln-transformed before analysis.

Table 2. Odds Ratios (95 %CI) of Unhealthy Phenotype in Overweight/Obese Adults According to the EDIP

	Quartiles					Continuous (Per One SD)[a]	P Value
	1	2	3	4	P-Trend		
N	101	101	101	100			
Median	0.16	0.44	0.67	0.97	-	-	-
Range	-0.24 to 0.33	0.33 to 0.55	0.56 to 0.79	0.80 to 1.86	-	-	-
Unadjusted	1.00	1.30 (0.73, 2.31)	2.37 (1.34, 4.19)	2.06 (1.16, 3.65)	0.003	1.38 (1.13 - 1.69)	0.002
Model 1[b]	1.00	1.24 (0.66, 2.31)	1.97 (1.06, 3.66)	1.98(1.07, 3.66)	0.013	1.35 (1.09 - 1.68)	0.007
Model 2[b]	1.00	1.18 (0.63, 2.22)	1.47 (0.76, 2.84)	1.34 (0.67, 2.64)	0.362	1.16 (0.90 - 1.48)	0.24

[a] SD of the EDIP was 0.36.
[b] Model 1: adjusted for age, sex, BMI, marital status. Model 2; additionally adjusted for energy intake.

tritional recommendations to reduced levels of inflammation induced by diet compared to using nutrient-food parameters (11).

MUO is characterized by higher both systemic and local inflammation compared to MHO (7-9). In our study, MUO individuals had a higher EDIP score compared to MHO people, suggesting a more pro-inflammatory dietary intake in this group. In addition, a higher adherence

Table 3. B-Coefficients (95% CIs) of the Association Between EDIP and Metabolic Syndrome Components

	EDIP (Per One SD)[a]	P Values
WC, cm		
Crude	0.13(-0.91, 1.17)	0.806
Model 1[b]	-0.05 (-0.76, -0.68)	0.887
Model 2[b]	-0.87 (-1.67, -0.08)	0.031
SBP, mmHg		
Crude	-0.05 (-0.22, 0.11)	0.521
Model 1	-0.07 (-0.22, 0.09)	0.409
Model 2	-0.11 (-0.28, 0.07)	0.223
DBP, mmHg		
Crude	0.09 (-0.03, 0.21)	0.138
Model 1	0.08 (-0.03, 0.20)	0.151
Model 2	0.03 (-0.01, 0.16)	0.640
Ln-FBS, mg/dL		
Crude	0.02 (0.01, 0.03)	< 0.001
Model 1	0.02 (0.01, 0.03)	0.001
Model 2	0.01 (-0.001, 0.02)	0.080
HDL, mg/dL		
Crude	-1.59 (-2.56, -0.62)	0.001
Model 1	-1.45 (-2.41, -0.49)	0.003
Model 2	-1.77 (-2.86, -0.68)	0.001
Ln-TGs, mg/dL		
Crude	0.02 (-0.02, 0.06)	0.336
Model 1	0.01 (-0.03, 0.05)	0.486
Model 2	-0.01 (-0.06, 0.03)	0.529

Abbreviations: DBP, diastolic blood pressure; FBS, Fasting blood sugar; SBP, systolic blood pressure; TGs, Triglycerides; WC, waist circumference.
[a] One SD of the EDIP was 0.36.
[b] Model 1 Adjusted for age, sex, BMI, marital status. Model 2 additionally adjusted for energy intake.

to the pro-inflammatory diet increased odds of MUO after adjusting for relevant covariates. This finding may be important clinically as it showed that MHO is a transient phenotype (5, 6), and more adherence to the pro-inflammatory diet may increase the odds of occurrence of cardio-metabolic disturbances in MHO, changing this phenotype to unhealthy. Longitudinal studies are needed to investigate whether the inflammatory potential of diet can put MHO individuals at greater risk of developing unhealthy phenotype.

The findings of this study suggested that the odds of high FBS increased by a higher pro-inflammatory diet. In a previous cross-sectional study conducted among Iranian adults, pro-inflammatory diet, assessed by DII, showed a positive weak association with 2-h post-load glucose but not with FBS and fasting insulin. No significant association was also observed between DII and odds of glucose intolerance or insulin resistance (21). Considering food groups instead of food parameters to assess the inflammatory potential of diet in this study may be responsible for the inconsistency of the findings of the two studies. Of previous studies investigating the association of DII and MetS components, a study conducted among police officers also showed higher odds of high FBS with higher DII score (13).

In this study, lower HDL-C and higher odds of low-HDL-C were associated with higher EDIP scores; the observed associations remained significant even after adjusting for energy intake. An inverse association between DII and HDL was suggested previously in a prospective (15) and a cross-sectional study (14). This observation may be due to the inverse associations of tea, coffee, dark yellow vegetables, leafy green vegetables, and fruit juice with EDIP. These food groups are rich in flavonoids, and flavonoids have been suggested to affect HDL-C metabolism (22).

No significant association was observed between EDIP and WC but after controlling for energy intake, every 1-SD increase in the EDIP score was associated with 0.87 cm reduction in WC and 36% lower odds of high WC in this study. In this study, a moderate positive correlation was observed between WC and energy intake ($r = 0.33$; $P < 0.001$), which was highest compared to other MetS components, while EDIP and WC were not correlated ($r = 0.012$; $P = 0.806$). Therefore, energy intake seems to be a more decisive factor for WC than EDIP. The mean WC in individuals in tertile 3 of DII was also shown to be 2.5 cm lower compared to those in the lowest tertile in a cross-sectional study conducted in Luxembourg. However, using a cut-point different from ours, they could not find any significant association with abdominal obesity (14). Ruiz-canela et al. in a population of adults older than ours showed that individuals in DII quintile 5 had higher WC than those in the first quintile ($P < 0.01$). In the study, no model was adjusted for BMI (12). A Polish-Norwegian (PNOS) cross-sectional study showed higher odds of abdominal obesity with higher DII in men (17). Other studies did not report any significant association between DII score and WC (13, 15, 16).

Some limitations should be mentioned in this study. The cross-sectional design of the study made it impossible to show any causal relationship. In addition, participants in our study were recruited from employees of two pharmaceutical companies that may limit the generalization of our findings. Drinking low-energy beverages, beer, and wine is not usual in Iranian populations and therefore, these components were not considered to construct the EDIP score. To increase the ability to use the EDIP in our population, we created food groups uniformly as it had been indicated (11, 18). However, some of the associations observed between food groups and inflammation may be due to the methods of food preparations that may differ

Table 4. Odds Ratios (95%CIs) of Metabolic Disturbances According to the EDIP

	Quartiles					Continuous (Per One SD)[a]	P Value
	1 (n = 101)	2 (n = 101)	3 (n = 101)	4 (n = 100)	P-Trend		
High WC							
Unadjusted	1.00	1.27 (0.73, 2.22)	1.49 (0.86, 2.60)	0.69 (0.39, 1.23)	0.290	0.89 (0.73, 1.09)	0.267
Model 1	1.00	1.22(0.59, 2.55)	0.93 (0.45, 1.94)	0.56 (0.28, 1.22)	0.109	0.81 (0.62, 1.05)	0.808
Model 2	1.00	1.07 (0.51, 2.34)	0.59 (0.27, 1.33)	0.32 (0.14, 0.74)	0.004	0.64 (0.46, 0.87)	0.005
High BP							
Unadjusted	1.00	1.32 (0.76, 2.30)	1.27 (0.73, 2.21)	1.35 (0.77, 2.35)	0.333	1.12 (0.92, 1.37)	0.245
Model 1	1.00	1.24 (0.69, 2.24)	0.93 (0.51, 1.69)	1.41 (0.78, 2.55)	0.389	1.11 (0.90, 1.37)	0.315
Model 2	1.00	1.20 (0.66, 2.18)	0.78 (0.41, 1.47)	1.12 (0.58, 2.15)	0.931	1.03 (0.81, 1.30)	0.806
High FBS							
Unadjusted	1.00	1.67 (0.89, 3.13)	3.81 (2.06, 7.03)	3.18 (1.72, 5.89)	< 0.001	1.54 (1.25, 1.91)	< 0.001
Model 1	1.00	1.80 (0.93, 3.47)	4.32 (2.25, 8.32)	3.08 (1.62, 5.86)	< 0.001	1.53 (1.23, 1.90)	< 0.001
Model 2	1.00	1.72 (0.88, 3.34)	3.19 (1.61, 6.32)	2.01 (0.97, 4.09)	0.031	1.28 (1.00, 1.63)	0.051
Low HDL-C							
Unadjusted	1.00	1.13(0.65, 1.96)	0.85 (0.49, 1.49)	2.42 (1.37, 4.27)	0.008	1.41 (1.15, 1.73)	0.001
Model 1	1.00	1.23 (0.66, 2.31)	1.01 (0.53, 1.94)	2.19 (1.15, 4.16)	0.030	1.44 (1.14, 1.81)	0.002
Model 2	1.00	1.24 (0.66, 2.33)	1.05 (0.52, 2.10)	2.27 (1.11, 4.63)	0.036	1.52 (1.17, 1.99)	0.002
High TGs							
Unadjusted	1.00	0.92 (0.52, 1.62)	1.55 (0.89, 2.71)	1.35 (0.77, 2.36)	0.130	1.23 (1.01, 1.50)	0.044
Model 1	1.00	0.89 (0.50, 1.58)	1.39 (0.79, 2.47)	1.30 (0.74, 2.31)	0.194	1.20 (0.98, 1.47)	0.076
Model 2	1.00	0.82 (0.46, 1.48)	0.94 (0.51, 1.75)	0.77 (0.40, 1.47)	0.496	0.98 (0.78, 1.24)	0.881

Abbreviations: DBP, diastolic blood pressure; FBS, Fasting blood sugar; SBP, systolic blood pressure; TGs, Triglycerides; WC, waist circumference.
[a] One SD of the EDIP was 0.36. Model 1 adjusted for age, sex, BMI, marital status. Model 2 additionally adjusted for energy intake.

from the methods used by our populations. There are also some concerns about using 24-hour dietary recall method to assess dietary intake (23). Three days dietary recalls may not be sufficient to show the long-term habitual dietary intakes (24).

In conclusion, a higher pro-inflammatory diet, assessed by food group intakes, was associated with higher odds of unhealthy phenotype in overweight/obese individuals. However, this association seems to be dependent on the total energy intake. In addition, the higher EDIP score was associated with increased odds of high FBS, low-HDL but decreased odds of high WC, independent of age, sex, BMI, marital status, and energy intake.

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