Correlation between Diet Quality and Metabolic Syndrome

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ABSTRACT

Background: The metabolic syndrome (MetS) is increasing with an alarming rate world wide. Since diet components' studies that focus on MetS have produced largely inconsistent results, assessing the whole diet than single nutrients on health can be more practical. The purpose of this study was to determine the association between diet quality and MetS components. **Methods**: This cross-sectional study included a total of 152 participants aged 20-55 years recruited from the endocrinology center of Tehran University of medical sciences. Dietary intake assessed by food frequency questionnaire (FFQ) was used to calculate healthy eating index 2010 (HEI-2010). Body mass index (BMI), weight, height, waist circumference, high density lipoprotein-cholesterol (HDL-c), triglycerides (TG), fasting blood glucose (FBG), and blood pressure were measured. **Results:** In this study HEI mean score was 55.26. Based on HEI-2010 values, diet quality was good in 0.7% of participants, needed improvement in 55.9%, and was poor in 43.4% of cases. Diet quality (HEI) was significantly and linearly related with systolic and diastolic blood pressure, TG, and BMI ($P < 0.05$). **Conclusions:** According to this study, low diet quality can be related to MetS components.

Keywords: *Metabolic syndrome; Diet quality, Obesity; FBG; Lipid profile*

Introduction

The metabolic syndrome (MetS) and obesity are steadily increasing in the world and have become a major public health problem (Grundy *et al.*, 2005). This syndrome (MetS) is characterized by the concurrent presence of cardiovascular risk factors that include abdominal obesity, high triglycerides, low high density lipoprotein-cholesterol (HDL-c), insulin resistance, glucose intolerance, and hypertension (Cameron *et al.*, 2004, Zainuddin *et al.*, 2011). MetS increases the risk of co-morbidities such as

cardiovascular diseases and type II diabetes, their risk have also been dramatically increased with combination of MetS parameters (Haffner, 2006, Isomaa *et al.*, 2001).

Because of the dramatically increasing prevalence of MetS and diabetes worldwide, urgent preventive and curative strategies are needed to tackle the basic causes of these diseases. Previous findings showed that lifestyle changes in overweight or obese individuals with MetS reduce cardiometabolic risk factors and incidence of diabetes (Kastorini *et al.*, 2011). Diet modification can be considered as one of the most effective lifestyle changes strategies.

An impressive body of evidence from epidemiological and clinical trials indicated that consumption of foods rich in antioxidants, omega-3, or minerals rather than sodium, present in the Mediterranean diet pattern protect people against MetS. The cumulative results of these studies highlight the importance of diet quality in reducing risk factors for cardiometabolic disorders (Abete *et al.*, 2011, Kastorini *et al.*, 2011). Diet quality indices are widely used. These indices evaluate the relationship between total diet and chronic disease risk factors; in fact, diet quality index is a strong predictor of coronary heart disease, cancer, diabetes, and other metabolic risk factors. A majority of studies used healthy eating index (HEI) for evaluation of diet quality (Arvaniti and Panagiotakos, 2008, Fransen and Ocké, 2008, McCullough *et al.*, 2002). This Index was released in mid 1990s with the aim to provide a single brief measure of overall dietary quality (Kennedy *et al.*, 1995). The HEI-2010 is a 12-component index including 9 adequacy and 3 moderation components (Reedy and Krebs-Smith, 2008).

The aim of this study was to determine the relationship between diet quality determined by the HEI-2010 and MetS components.

Materials and Methods

Study design and participants: In this cross-sectional study, a total of 152 participants, aged

between 20-55 years were recruited from September 2012 to May 2013. Sample size was estimated based on the number of patients/year referred to the endocrinology center of Tehran University of medical sciences. Participants were selected through sequential sampling method (sampling continued until the desired sample size was achieved) based on the exclusion criteria. Eligible participants did not have history of coronary artery disease, acute or chronic renal failure, history of acute infection within the previous seven days, acute or chronic hepatic failure, hematological disorder, chronic inflammatory or autoimmune disease, uncontrolled thyroid, any known malignancy, and pregnancy. They were also not breast feeding, at menopausal state, smoking, professional athletes, using medications for dyslipidemia or hypertension, using hypnotics, sedatives or immunosuppressive, and having a special diet prescribed by a dietitian.

*Measurements***:** Dietary intake was determined by using the food frequency questionnaire (FFQ). Participants self-reported the average consumption of specific food amount over the past 12 months. The HEI is a nutritional quality measurement tool (McGuire, 2011). The HEI-2010 has 12 components (**Table 1**), including 9 adequacy (dietary components to increase) and 3 moderation components (dietary components to decrease) (Reedy and Krebs-Smith, 2008). The scoring standards were density-based and for the adequacy components individuals with an intake at the recommended level received a maximum score whereas decreased intake of moderation components increased the score. In other words, higher scores for HEI-2010 components indicated a higher conformance with current dietary guidelines (Reedy and Krebs-Smith, 2008).

The composite HEI-2010 score can potentially range from a minimum of zero to a maximum of 100. An HEI-2010 score of over 80 implies a 'good' diet, an HEI-2010 score between 51 and 80 implies a diet that 'needs improvement', and an HEI-2010 score less than 51 implies a 'poor'

diet. The food-based dietary guidelines and nutrition education in Iran cover mainly the general qualitative dietary recommendations suggested by the United States Department of Agriculture.

Blood samples were collected in the morning, after 8-12 h of overnight fasting and 20 minutes of supine rest. The venous blood sample was drawn into EDTA tubes and promptly centrifuged at 4 °C. Fasting blood glucose (FBG) was measured by the glucose oxidase method (Pars Azmoon, Iran) with an auto analyzer device (Hitachi 902/ Japan-Germany). Serum total cholesterol (TC), triglyceride (TG), high-density lipoprotein-cholesterol (HDL-c), and low density lipoprotein-cholesterol (LDL-c) were measured by enzymatic methods using the auto analyzer device (Hitachi 902/ Japan-Germany).

Weight was measured by balanced beam scale (Seca Corp. Scale, Germany) in light clothing height was then measured using standard stadiometer. Body mass index (BMI) was calculated as body weight in kg divided by height in meters squared (kg/m^2). Waste circumference (WC) was measured by a flexible and non-elastic tape measure in the midline between the lower rib margin and the iliac crest.

After resting quietly in a sitting position for 5 minutes, the maximum inflation level (MIL) and two consecutive blood pressures were measured and the average was considered as the blood pressure variable.

Data analysis: Data were analyzed with the statistical package STATA version 11. Mean and standard deviation were calculated as descriptive data. Linear regression and quantile regression were used to assess the association between HEI-2010 score and MetS components. P-value for linear and quartile trends were then applied for evaluating the association of HEI-2010 through quartiles of diet quality.

Ethical considerations: All participants were informed about the aims and procedures of the study; a written informed consent was also gathered from them to participate in the study. The study protocol was approved by the ethics committee of Tehran University of medical sciences.

Results

Demographic characteristics and biochemistry parameters of participants are presented in **Table 2**. The mean HEI-2010 score was 55.26 ± 12.13 (**Table 3**). The HEI-2010 scores for 43.4% of participants were classified as "poor diet" and 55.9% were in "needs improvement" group. According to the HEI-2010 scores, only 0.7% of individuals were classified as having a "good diet" (data not shown).

There were significant linear trends between HEI-2010, systolic blood pressure (SBP), and diastolic blood pressure (DBP), TG and BMI ($P < 0.05$). There were also significant quartile trends between HEI-2010, DBP, and BMI ($P < 0.001$). With increasing HEI-2010, there was a significant linear decrease in BMI ($P < 0.001$), SBP ($P < 0.007$), DBP ($P = 0.001$) and TG ($P = 0.02$) (**Table 4**).

A change of score in each individual food group resulted in a significant increase ($P < 0.0001$) in total diet quality (**Table** 5). For whole fruit, total vegetables, bean and green, whole grain, dairy, fatty acid, refined grain, and empty calories there was a ≥1-pointchange in HEI-2010 score for that food group ($P < 0.0001$).

Table 1. Healthy Eating Index-2010 components and standards for scoring

Component	Maximum point	Maximum score	Minimum score
Total fruit	5	≥0.8 cup/1,000 kcal	No fruit
Whole fruit	5	≥0.4 cup/1,000 kcal	No whole fruit
Total vegetables	5	≥1.1 cup/1,000 kcal	No vegetables
Greens and beans	5	≥ 0.2 cup/1,000 kcal	No dark green vegetables or beans and peas
Whole grain	10	≥1.5 Oz/1,000 kcal	No whole grains
Dairy	10	≥1.3 cup/1,000 kcal	No dairy
Total protein foods	5	≥2.5 Oz/1,000 kcal	No protein foods
Seafood and plant proteins	5	≥0.8 Oz/1,000 kcal	No seafood or plant proteins
Fatty acids	10	(PUFAs + MUFAs)/SFAs >2.5	(PUFAs + MUFAs)/SFAs <1.2
Refined grains	10	≤1.8 Oz/1,000 kcal	≥4.3 Oz/1,000 kcal
Sodium	10	≤1.1 g/1,000 kcal	≥2.0 g/1,000 kcal
Empty calories	20	≤19% of energy	≥50% of energy

PUFAs: Polyunsaturated fatty acids; MUFAs: Monounsaturated fatty acids; SFAs: Saturated fatty acids

Table 2. General characteristics and biochemistry parameters among participants

Parameters	Mean ± SD
Age (year)	35.4 ± 7.3
Height (cm)	172.1 ± 7.9
Weight (kg)	81.5 ± 14.7
Waist circumference (cm)	98.9 ± 11.2
Body mass index (kg/m^2)	27.4 ± 4.3
Fasting blood glucose (mg/dL)	97.9 ± 29.6
Triglyceride (mg/dL)	147.2 ± 82.5
High density lipoprotein-cholesterol (mg/dL)	54.3 ± 7.4
Systolic blood pressure (mmHg)	127.2 ± 14.7
Diastolic blood pressure (mmHg)	82.3 ± 9.9

Table 3. Total healthy eating index-2010 and component scores

Component scores	Range of score	Mean ± SD	%Mean ± SD
Sodium	0-10	7.2 ± 2.7	72.2 ± 27.1
Total fruit	0-5	2.86 ± 1.60	80.9 ± 285.9
Whole fruit	0-5	3.87 ± 1.23	77.8 ± 24.6
Refined grain	0-10	1.2 ± 2.4	13.2 ± 24.5
Whole grain	0-10	1.58 ± 0.94	15.8 ± 9.4
Dairy	0-10	5.29 ± 3.06	53.4 ± 30.7
Seafood and plant protein	0-5	2.38 ± 1.70	48.2 ± 34.0
Total protein food	0-5	4.29 ± 0.50	85.85 ± 10.10
Total vegetables	0-5	2.95 ± 1.00	59.0 ± 20.1
Greens and bean	0-5	3.20 ± 1.46	64.4 ± 29.1
Fatty acid	0-10	4.64 ± 3.81	46.0 ± 38.3
Empty calories	0-20	15.68 ± 5.31	78.2 ± 26.5
HEI-2010	0-100	55.26 ± 12.13	55.26 ± 12.13

Table 4. Association between diet-quality quartiles and metabolic syndrome components

Components	HEI-2010 quartile score				Linear trend		Quartile trend	
	1 (n=38)	2 (n=38)	3 (n=38)	4 (n=38)	β	P-value	β	P-value
WC (cm)[a]	102.4 ± 1.6	104.8 ± 1.5	94.6 ± 1.9	93.5 ± 1.5	0.01	0.94	0.10	0.70
FBG (mg/dL)	106.3 ± 8.1	93.0 ± 1.0	94.0 ± 1.7	98.5 ± 5.3	-0.03	0.3	-0.03	0.12
DBP (mmHg)	86.7 ± 1.4	84.9 ± 1.4	78.2 ± 1.7	79.4 ± 1.5	-0.40	<0.001	-0.38	0.001
SBP (mmHg)	130.3 ± 2.2	131.4 ± 2.0	123.6 ± 2.6	123.5 ± 2.3	-0.18	0.007	-0.10	0.17
HDL-c(mg/dL)[a]	53.3 ± 1.2	52.7 ± 1.1	54.4 ± 1.1	56.7 ± 1.3	0.21	0.08	0.07	0.63
TG (mg/dL)	153.7 ± 12.5	171.3 ± 11.8	132.3 ± 16.4	128.2 ± 13.1	-0.02	0.02	-0.008	0.47
BMI (kg/m^2)	29.4±0.65	29.4±0.6	26.1±0.76	24.7±0.59	-1.33	<0.001	-1.23	<0.001

WC: waste circumference; FBG: fasting blood glucose; DBP: diastolic blood pressure; SBP: systolic blood pressure; HDL-c: High density lipoprotein-cholesterol; TG: triglyceride; [a]:WC and HDL Adjusted for age, BMI and Gender

Table 5. Association between diet-quality quartiles and HEI-2010 components

HEI components	HEI-2010 quartile score				Linear trend		Quartile trend	
	1 (n=38)	2 (n=38)	3 (n=38)	4 (n=38)	β	P-value	β	P-value
Total fruit	1.60 ± 0.13	1.80 ± 0.16	3.40 ± 0.24	4.60 ± 0.10	0.99	<0.001	0.99	<0.001
Whole fruit	2.98 ± 0.15	3.16 ± 0.20	4.30 ± 0.17	5.00 ± 0.00	1.00	<0.001	1.00	<0.001
Total vegetables	2.47 ± 0.11	2.85 ± 0.15	2.83 ± 0.13	3.63 ± 0.18	1.00	<0.001	1.00	<0.001
Greens and bean	2.18 ± 0.14	2.29 ± 0.17	3.71 ± 0.22	4.64 ± 0.11	1.00	<0.001	1.00	<0.001
Whole grain	1.48 ± 0.11	1.50 ± 0.12	2.00 ± 0.17	1.30 ± 0.16	1.00	<0.001	1.00	<0.001
Dairy	3.00 ± 0.24	3.60 ± 0.29	6.04 ± 0.47	8.50 ± 0.33	1.00	<0.001	1.00	<0.001
Total protein food	4.39 ± 0.04	4.33 ± 0.05	4.01 ± 0.08	4.44 ± 0.10	0.99	<0.001	0.99	<0.001
Seafood and plant proteins	1.18 ± 0.16	1.53 ± 0.20	2.68 ± 0.25	4.14 ± 0.18	0.99	<0.001	1.00	<0.001
Fatty acid	3.65 ± 0.53	3.65 ± 0.60	4.91 ± 0.68	6.35 ± 0.55	1.00	<0.001	1.00	<0.001
Refined grain	0.14 ± 0.10	1.15 ± 0.28	1.90 ± 0.46	1.89 ± 0.50	1.00	<0.001	1.00	<0.001
Sodium	5.60 ± 0.44	7.40 ± 0.36	7.30 ± 0.50	8.50 ± 0.30	0.99	<0.001	1.00	<0.001
Empty calories	12.38 ± 0.86	15.77 ± 0.87	15.57 ± 0.89	18.98 ± 0.34	1.00	<0.001	1.00	<0.001

Discussion

The results showed that mean HEI-2010 score was 55.26 (diet needs improvement), which is lower than US women with a mean HEI-2010 score of 66.6 (Basiotis *et al.*, 2002). Similar to our results, Lin et al, in Macau reported that the average score of HEI-2010 was 66.0 (Lin *et al.*, 2004). Another study showed that HEI-2010 score was 58.8 for people with diabetes living in North Cyprus (Tardivo *et al.*, 2010).

As mentioned in the present study the HEI-2010 scores for 43.4% of participants were classified as

"poor diet", 55.9% were in "needs improvement", and only 0.7% of individuals were classified as having a "good diet". The results are consistent with the findings of Tardivo AP et al, they reported that only 3% of diets were of good quality, while in 48.5% they needed improvement, and in 48.5% they were of poor quality (Tardivo *et al.*, 2010). Further, the study conducted in Sao Paulo State, Brazil represented that only 5% of participants had a good diet, 74% had a diet that needed improvement, and 21% had a poor diet (Fisberg *et al.*, 2006).

According to the results of the present study, the HEI-2010 component scores were from highest to lowest included total protein food (85.85%), total fruit (80.9%), empty calories (978.2%), whole fruit (77.8%), sodium (72.2%), greens and bean (64.4%), total vegetables (59%), dairy (53%), sea food and plant protein (48.2%), fatty acid (46%), whole grain (15.8), and refined grain (13.2%). Previous studies which used the HEI-2005 demonstrated that component scores from highest to lowest were cholesterol (9.5), sodium (7.9), variety (6.5), fat (6.3), cereals (6.2), fruit (6.1), saturated fat (4.6), vegetables (4.6), milk (3.7), and meat (3.3) (Direktör and Özer, 2013).

In another study carried out by Ağören, the HEI-2005 component scores from highest to lowest were cholesterol (8.2), variety (7.2), saturated fat (6.1), sodium (6.0), fat (5.7), meat (4.9), milk (4.8), fruit (4.8), cereals (4.5) and vegetables (4.0) (Ağören, 2010). According to these studies, milk, meat, and vegetable consumption were insufficient. In the present study, the overall low diet quality was most likely due to inadequate consumption of total vegetables (59%), dairy (53%), sea food and plant protein (48.2%), whole grain (15.8%), and refined grain (13.2%).

To the best of our knowledge, this is the first study assessing diet quality by HEI-2010. Due to lack of similar studies, the results were compared with the results of studies that have investigated diet quality by HEI-2005. However, the consistency of results in these studies represented a low quality diet. Regarding the fact that poor diet quality has been considered as the main predictor of obesity,

improving nutritional status is necessary.

The key finding of this study was the reverse relation of diet quality (HEI-2010) with blood pressure (systolic and diastolic), TG, and BMI. With increasing HEI-2010 score, there was a significant decrease in BMI, SBP, DBP, and TG. This study using the most recent measurement tool of diet quality (HEI-2010), confirmed earlier findings and showed that diet quality was inversely associated with metabolic syndrome parameters (Drewnowski *et al.*, 2009, Nicklas *et al.*, 2012, Zamora *et al.*, 2011) .

Individuals with a higher diet quality were less likely to have elevated blood pressure, TG, and BMI. However, there were no difference between the HEI-2010 quartiles for HDL-c, LDL-c, FBG concentrations, and WC.

The HEI-2010 is designed to evaluate diet as a whole consisting of 12 components; therefore, the same score of HEI may not reflect the identical dietary profile. In other words, a similar score can be resulted from different combinations of the 12 components. This can explain the inconsistent results relating dietary quality to health outcomes and why some disease risk factors were not significantly associated with HEI-2010 (Nicklas *et al.*, 2012).

The major limitations of this study were small sample size and the cross-sectional study design which limited the disquisition of cause-effect relationship between HEI-2010 and MetS parameters. Bias in reporting the food intakes by overweight and obese individuals could be another limitation of this study. However, as far as we know, this is the first study that assessed the relationship between diet quality by using the HEI-2010 and individual risk factors for cardiovascular disease and the MetS.

Conclusions

The present study introduced diet modification as an effective strategy to reduce metabolic syndrome caused by metabolic risk indicators. Based on the results of this study diet quality is inversely associated with several metabolic syndrome risk factors.

Authors' contributions

Yosaee S contributed in the conception of the work. Erfani MR searched data bases and extracted findings. Bazrafshan MR and Entezami N wrote the manuscript. Alinavaz M managed the project and drafted the manuscript. Akbai M contributed in design, collection, and analysis of data. Soltani S and Djafarian K revised the manuscript. All authors read the paper and verified the final version of the manuscript and agreed for all aspects of the work.

Conflicts of interest

The authors declare no conflict of interest and no financial competing interest.

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