

Diet Diversity Score May Not be a Good Indicator of Healthy Diet

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Abstract

Background: The close relationship between diet and disease emphasizes the need for optimal diet evaluation. The aim of this study was to compare the efficiency by which each of Healthy Eating Index (HEI)-2010, Diet Quality Index-International (DQI), Mediterranean Diet Score (MDS), and Diet Diversity Score (DDS) evaluates the diet.

Methods: In a cross-sectional design, 438 adults aged 20-50 years were recruited. Dietary intakes were assessed using a semi-quantitative food frequency questionnaire. HEI-2010, DQI, MDS, and DDS were calculated and scored according to their corresponding criteria.

Results: Energy (1917±554 kcal to 2898±933 kcal), saturated fats (17.0±6.8 g to 28.1±11.5 g), and cholesterol (244±195 g to 414±343 g) increased across tertiles of DDS and energy (2017±699 kcal to 2621±748 kcal) increased across tertiles of DQI. In contrast, saturated fats decreased (23.9±12.0 g to 20.8±8.1 g for HEI-2010 and 23.7±10.0 g to 20.5±10.4 g for MDS), but energy and cholesterol did not change significantly across tertiles of HEI-2010 and MDS. Other nutrients either did not change or changed appropriately across tertiles of the different indices.

Conclusion: DDS and, to a less extent, DQI may not be good indicators of healthy diet especially in terms of obesity and cardiovascular diseases.

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Introduction

The close relationship between healthy diet and prevention of chronic disease emphasizes the need for optimal diet evaluation.¹ Diet evaluation is increasingly being used by using diet quality indices, including Healthy Eating Index (HEI), Mediterranean Dietary Score (MDS), Diet Quality Index, and Dietary Diversity Score (DDS). Each of these measurements uses different criteria for scoring the diet and they are used in different applications according to their criteria. Although these indices seem to focus on different aspects of healthy diet, they all were developed to evaluate healthfulness of the diet.

HEI was initially designed as a tool for assessing the adherence to the Dietary Guidelines

for Americans. Similar to HEI, MDS predicts the risk of the development and mortality from chronic diseases.^{2,3} Diet Quality Index was primarily established to evaluate the diet for the risk factors of chronic disease.⁴ However, to make a globally accepted index, later, Diet Quality Index-International (DQI) was developed, considering both aspects of healthfulness and sufficiency of food. Therefore, DQI can be used as a suitable index for estimating the risk of both under-nutrition and chronic diseases.⁴ DDS was established on the basis of the concept that more variety and diversity in the diet decreases the risk of malnutrition,⁵ but later some studies found an association between higher scores of DDS and risk of obesity.^{6,7}

Previous studies have shown the relationships

among HEI and metabolic syndrome,⁸ cardiovascular disease (CVD), cancer, and all-cause mortality,⁹ DQI and obesity¹⁰ and risk of mortality,¹¹ MDS and CVD risk,¹² and DDS and metabolic syndrome,¹³ CVD risk factors,⁵ and incidence of type 2 diabetes.¹⁴ However, no comparison has ever been made between these indices to see how efficiently these indices evaluate the diet. The aim of the present study was to compare the efficiency by which HEI-2010, DQI, MDS, and DDS evaluate the diet in terms of energy and nutrient intake.

Materials and Methods

Subjects

This cross-sectional study was conducted between November 2013 and March 2014 on 438 males and females aged 20-50 years in Shiraz, Iran. Participants were selected by stratified multistage random sampling from households living in 9 municipal districts of Shiraz. The samples were taken from all districts according to the population size of the districts. Then, within each district, using a map, the houses were selected by random sampling from blocks located on that district. In each selected house, all adults who met the inclusion criteria were included. Pregnant or lactating women, individuals with special diets or diseases, and those taking medications that affect appetite or dietary intake were not included in the study. All participants gave informed written consent. The project was approved by Ethics Committee of Shiraz University of Medical Sciences (Project ID: 92-6865) and conducted in accordance with the ethical principles of World Medical Association Declaration of Helsinki of 1964¹⁵ and all subsequent revisions.

Data Collection

Dietary information was gathered at participants' residence through interview by expert dietitians using a semi-quantitative 168-item food frequency questionnaire (FFQ), which has already been evaluated for validity and reliability in previous studies.¹⁶ The FFQ consisted of a list of food items with the serving sizes commonly used by Iranians. Participants were asked to report the frequency of consumption of each food item during the previous year on a daily, weekly, or monthly basis. Nutrient composition of foods was determined by Nutritionist IV, version 3.5.2 (Hearst Corp., San Bruno, CA). FFQs with incomplete information were excluded. Family affluence scale (FAS) was determined according to a valid questionnaire.¹⁷

Dietary Indices

HEI-2010 was calculated according to the criteria proposed by the Center for Nutrition Policy and Promotion and the U.S. Department of Agriculture.¹⁸

DQI was scored as described by Kim et al.⁴ MDS was calculated based on a 10-point scale according to the procedure described by Panagiotakos and colleagues.¹² For calculating the DDS, food groups were divided into 19 subgroups from 5 main groups: cereals/grains, meat and meat alternatives, dairy, vegetables, and fruit, as described in full details by Conklin et al.¹⁴

Statistical Analysis

Data were analyzed by SPSS software, version 16.0 (SPSS Inc., Chicago, IL, USA) and checked for the normality, using the Kolmogorov-Smirnov test; also, non-parametric tests were used where needed. Tertiles of dietary indices were determined based on distribution of the subjects in the dietary indices. To assess the difference in energy and nutrient content between tertiles of dietary indices, we used one-way ANOVA. $P < 0.05$ was considered as statistically significant.

Results

The participants were 438 individuals (199 (45.4%) males and 239 (54.6%) females) with the mean age of 35.0 ± 9.1 years. Almost half of the subjects belonged to low socio-economic groups; 260 (59.4%) had school-based education and 178 (40.6%) had academic education. Less than one third of them (28.8%) were single (Table 1).

Table 1: Characteristics of the study subjects (n=438)

	Mean±SD or n (%)
Age (y)	35.0±9.1
Sex, n (%)	
Male	199 (45.4)
Female	239 (54.6)
Marital status, n (%)	
Single	126 (28.8)
Married	312 (71.2)
Education, n (%)	
School	260 (59.4)
College	178 (40.6)
Job, n (%)	
Unemployed	200 (45.7)
Employed	238 (54.3)
Family affluence scale ¹ , n (%)	
Low	214 (49.0)
Moderate	181 (41.4)
High	43 (9.6)
Dietary indices	
HEI-2010	66.7±10.2
DQI	65.0±10.3
MDS	26.9±4.1
DDS	5.8±1.4

¹Family affluence scale was determined as described in Methods.

Table 2 shows energy and nutrient consumption across the tertiles of dietary indices. Energy, carbohydrates, and protein did not significantly change across the tertiles of HEI-2010, but fat (84.7 ± 52.7 g

Table 2: Daily intake of energy, macro- and micro-nutrients across tertiles (T) of dietary indices (n=145 in each tertile)¹

	HEI			DQI		
	T1	T2	T3	T1	T2	T3
Energy (kcal)	2489±1045	2278±760	2307±698	2017±699	2437±937	2621±748‡
Carbohydrate (g)	366±151	350±114	354±115	283±90.2	361±125	427±119‡
Protein (g)	77.4±31.1	75.4±38.4	82.3±28.6	66.4±25.0	81.5±31.9	87.4±26.5‡
Fat (g)	84.7±52.7	69.5±34.0	68.4±24.4‡	72.8±37.1	79.7±49.0	69.8±27.2
Fiber (g)	19.9±9.1	21.5±6.8	24.2±8.3‡	15.9±5.2	22.2±7.4	27.7±7.6‡
Saturated fats (g)	23.9±12.0	20.8±10.2	20.8±8.1*	21.6±10.3	23.1±11.5	20.7±8.2
Cholesterol (g)	322±262	327±398	339±313	309±324	391±441	291±146*
MUFA (g)	26.1±14.9	21.6±12.6	21.2±8.4†	23.3±13.8	24.7±13.3	21.0±9.0*
EPA & DHA (g)	0.06±0.07	0.09±0.12	0.09±0.10†	0.07±0.11	0.09±0.10	0.08±0.09
Vitamin A (µg RE)	1947±1744	2192±1307	2487±1352†	1588±1059	2434±1768	2647±1402‡
Vitamin C (mg)	200±121	231±105	264±126‡	162±87	232±99	304±127‡
Vitamin B ₁₂ (µg)	5.3±5.9	5.6±6.0	5.6±5.2	4.5±4.4	5.6±5.7	6.6±7.2*
Folic acid (µg)	302±167	324±125	363±137†	251±92	341±165	400±131‡
Calcium (mg)	775±322	794±250	935±369‡	688±254	870±340	946±298‡
Magnesium (mg)	280±120	285±85	312±99*	233±74	296±98	348±98‡
Potassium (mg)	3671±1735	3867±1274	4304±1462†	3081±1096	3957±1492	4813±1397‡
Iron (mg)	17.6±7.9	16.9±6.2	17.2±5.7	13.7±4.9	17.9±7.3	20.1±5.8‡
Zinc (mg)	8.6±3.9	8.3±3.2	9.0±2.8	7.4±2.9	8.9±3.7	9.6±2.9‡

Data are presented as means±standard deviation (SD). The difference in energy and nutrients between the tertiles of dietary indices was examined by one-way ANOVA. *, †, and ‡ indicate P<0.05, <0.01, and <0.001, respectively. HEI, Healthy Eating Index; DQI, Diet Quality Index; DDS, Diet Diversity Score; MDS, Mediterranean Diet Score; MUFA, monounsaturated fatty acids; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

Table 2: Continued....

	MDS			DDS		
	T1	T2	T3	T1	T2	T3
Energy (kcal)	2371±782	2298±867	2409±892	1917±554	2264±663	2898±933‡
Carbohydrate (g)	351±118	347±136	373±127	291±90.1	347±98.7	434±141‡
Protein (g)	77.0±27.8	78.1±32.5	80.4±28.0	61.8±19.6	75.6±24.3	98.1±30.5‡
Fat (g)	78.4±33.9	71.8±35.0	72.5±47.5	60.1±25.6	69.6±29.5	92.7±49.6‡
Fiber (g)	19.4±6.9	21.5±8.1	24.7±9.0‡	16.3±5.4	22.4±6.7	27.1±8.6‡
Saturated fats (g)	23.7±10.0	21.3±10.3	20.5±10.4†	17.0±6.8	20.3±8.1	28.1±11.5‡
Cholesterol (g)	331±294	351±423	311±247	244±195	339±400	414±343‡
MUFA (g)	24.6±12.2	22.1±12.1	22.3±12.7*	18.6±9.1	21.9±11.0	28.5±14.0‡
EPA & DHA (g)	0.06±0.08	0.07±0.10	0.11±0.10‡	0.05±0.07	0.08±0.10	0.11±0.11‡
Vitamin A (µg RE)	1900±1290	2230±1466	2552±1751‡	1425±973	2300±1345	2939±1712‡
Vitamin C (mg)	212±121	226±111	258±124†	165±88	240±102	293±130‡
Vitamin B ₁₂ (µg)	5.0±4.2	5.6±6.4	6.1±6.8	3.5±2.7	4.8±3.8	8.4±8.5‡
Folic acid (µg)	294±145	324±128	374±154‡	241±80	339±147	413±147‡
Calcium (mg)	791±292	821±346	898±332‡	620±211	812±189	1073±345‡
Magnesium (mg)	273±87	285±105	319±111‡	220±58	288±77	368±104‡
Potassium (mg)	3645±1290	3838±1433	4370±1727‡	2875±857	3932±1065	5044±1626‡
Iron (mg)	16.6±6.6	16.9±6.7	18.2±6.6*	13.9±4.4	16.6±5.9	21.3±7.1‡
Zinc (mg)	8.5±3.4	8.5±3.4	8.9±3.3	6.7±2.2	8.3±3.0	10.9±3.2‡

Data are presented as means±standard deviation (SD). The difference in energy and nutrients between the tertiles of dietary indices was examined by one-way ANOVA. *, †, and ‡ indicate P<0.05, <0.01, and <0.001, respectively. HEI, Healthy Eating Index; DQI, Diet Quality Index; DDS, Diet Diversity Score; MDS, Mediterranean Diet Score; MUFA, monounsaturated fatty acids; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.

to 68.4±24.4 g), saturated fatty acids (23.9±12.0 g to 20.8±8.1 g), and monounsaturated fatty acids (MUFA) (26.1±14.9 g to 21.2±8.4 g) significantly decreased and fiber (19.9±9.1 g to 24.2±8.3 g), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (0.06±0.07 g to 0.09±0.10 g), vitamin A (1947±1744 µg RE to 2487±1352 µg RE), vitamin C (200±121 mg to 264±126 mg), folic acid (302±167 µg to 363±137 µg), calcium

(775±322 mg to 935±369 mg), magnesium (280±120 mg to 312±99 mg), and potassium (3671±1735 mg to 4304±1462 mg) significantly increased across the tertiles of HEI-2010. For DQI, energy (2017±699 kcal to 2621±748 kcal), carbohydrates (283±90.2 g to 427±119 g), protein (66.4±25.0 g to 87.4±26.5 g), fiber (15.9±5.2 g to 27.7±7.6 g), vitamin A (1588±1059 µg RE to 2647±1402 µg RE), vitamin C (162±87 mg

to 304±127 mg), vitamin B₁₂ (4.5±4.4 µg to 6.6±7.2 µg), folic acid (251±92 µg to 400±131 µg), calcium (688±254 mg to 946±298 mg), magnesium (233±74 mg to 348±98 mg), potassium (3081±1096 mg to 4813±1397 mg), iron (13.7±4.9 mg to 20.1±5.8 mg), and zinc (7.4±2.9 mg to 9.6±2.9 mg) significantly increased while cholesterol (309±324 g to 291±146 g) and MUFA (23.3±13.8 g to 21.0±9.0 g) significantly decreased across the tertiles. For MDS, fiber (19.4±6.9 g to 24.7±9.0 g), EPA and DHA (0.06±0.08 g to 0.11±0.10 g), vitamin A (1900±1290 µg RE to 2552±1751 µg RE), vitamin C (212±121 mg to 258±124 mg), folic acid (294±145 µg to 374±154 µg), calcium (791±292 mg to 898±332 mg), magnesium (273±87 mg to 319±111 mg), potassium (3645±1290 mg to 4370±1727 mg), and iron (16.6±6.6 mg to 18.2±6.6 mg) significantly increased and saturated fats (23.7±10.0 g to 20.5±10.4 g) and MUFA (24.6±12.2 g to 22.3±12.7 g) significantly decreased across the tertiles. Energy and all of the nutrients significantly increased across the tertiles of DDS. For instance, energy (1917±554 kcal to 2898±933 kcal), saturated fats (17.0±6.8 g to 28.1±11.5 g), and cholesterol (244±195 g to 414±343 g) increased across tertiles of DDS.

Discussion

In the current study, the potential of HEI-2010, DQI, MDS, and DDS in evaluating healthfulness of the diet was compared. The results showed that HEI-2010 and MDS evaluated the diet better than DQI and DDS. Higher scores of DQI were associated with higher intake of energy and higher scores of DDS were associated with higher intake of energy, cholesterol, and saturated fats. Individuals who adhered more strictly to nutrition guidelines had also healthier eating habits.

Intake of most vitamins and minerals increased across the tertiles of all dietary indices, suggesting that these indices can be used as tools for assessing the diet quality. Although the name and components of each of the dietary indices used in this study are different, the main objective of the establishment and the overall usage of them are more or less similar. These indicators can be interchangeably used in dietary assessments when determination of diet quality is required.¹⁹⁻²¹ Nonetheless, results of the current study showed that some of these indicators may have negative effects. For instance, DDS had two weaknesses. First, higher DDS was associated with greater energy intake. This means that increasing DDS may not lead to better health situation as individuals may get overweight and obesity.²² Second, greater DDS was associated with higher intakes of saturated fats and cholesterol, meaning that high DDS may increase the risk of CVD.^{23,24}

Dietary diversity is an essential component of healthy diets and it has been validated as a useful

tool for estimating the nutrient adequacy of diets.²⁵ A number of previous studies have reported an inverse association of DDS with obesity and abdominal obesity,²⁶ metabolic syndrome,¹³ CVD risk factors,⁵ and the incidence of type 2 diabetes.¹⁴ In contrast, there are also reports that are in agreement with the findings of this study. For instance, in a cross-sectional study, BMI, waist circumference, and energy consumption significantly increased concomitant to the increase in diet diversity.⁶ Also, in a large prospective cohort, greater food diversity was associated with higher gain in waist circumference.⁷ The obesogenic effect of high diversity diets is due to the so-called “sensory-specific satiety” which relies on the fact that the sensation of satiation from one food does not cause satiation to other foods and thus when a new type of food is consumed at the same meal, the person obtains a kind of pleasure and continues eating until a level of satiation occurs for that food. Hence, supplying a variety of foods at meals can result in overconsumption and, in long-term, obesity. However, although the increase of energy intake in high diversity diets seems reasonable, the energy-density of foods is also important.^{27,28} Consuming a variety of nutrient-dense, calorie-low foods prevents weight gain while eating calorie-dense foods can promote obesity.

The increase in energy intake was also observed in higher DQI levels but to a less extent than that of DDS (30% vs. 50% increase in energy intake in the 3rd compared to the 1st tertile). Nevertheless, compared to DDS, DQI was a better diet evaluation tool because higher DQI was not associated with higher saturated fats and cholesterol intake. None of HEI-2010 and MDS had drawbacks of DDS, but HEI-2010 showed a non-significant increase in cholesterol intake across the tertiles, suggesting that MDS may be a better measurement. Unfortunately, MUFA intake did not increase across the tertiles of various indices, except for DDS. Low MUFA intake was probably due to low consumption of olive oil in Iranian population. Olive oil is expensive and is not affordable by most people. On the other hand, many people are not aware of its health benefits. Moreover, consumption of MUFA has not been accredited in these indices and emphasis has mostly been laid upon reduction of total and saturated fats and the increase of PUFA.

Strengths and Limitations

This study had some strengths. The quality of diet was assessed by a valid 168-item FFQ which evaluated the diet during the last year, allowing determination of dietary intakes with more accuracy. Also, the semi-quantitative feature of the FFQ quantitatively determined the amounts of energy and nutrients consumed. Limitations of this study included self-reported dietary intake that may compromise the validity of the results, the reliance on the person's

memory for foods consumed during the last year, the small sample size, and limited generalizability of the findings.

Conclusion

This study showed that DQI and DDS may not accurately indicate the healthfulness of the diet because they give higher scores to diets that promote obesity and cardiovascular diseases. Scores of DQI and particularly DDS need to be used and interpreted with caution.

Future Studies

Future studies are required to be conducted to confirm these results regarding shortcomings of the DDS and DQI scoring system. Accordingly, studies are needed to revise and rectify the scoring criteria of defective indices. The association between dietary indices and cardiometabolic risk factors is also needed to be considered in future investigations.

Conflict of Interest: None declared.

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