The Relationship between Energy-Adjusted Dietary Inflammatory Index (E-DII) with Quality of Life and Inflammatory Markers among Overweight and Obese Iranian Women

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Research

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Abstract

Background

Overweight and obesity are associated with higher levels of inflammatory markers, inflammatory diseases, and lower quality of life. Recent investigations have shown that diet can modify these complications and improve quality of life.

Objective

The objective of this study was to investigate associations between Energy-Adjusted Dietary Inflammatory Index (EDII) with quality of life and serum inflammatory markers.

Methods

In the current cross-sectional study, a total of 280 females from health centers in Tehran, Iran (2018) were selected for the study using a multistage cluster random sampling method. The EDII was computed based on dietary intake, assessed by a previously validated 147-item food frequency questionnaire (FFQ). Before calculating EDII, a residual method was used to adjust energy intake. SF-36 questionnaires were used for evaluating quality of life. Concentrations of high-sensitivity C-reactive protein (hs-CRP) were determined using collected serum samples.

Results

The mean age of the study participants was 36.30 ± 8.05 years. Analyses were performed using multivariable linear regression, adjusting for age, weight, physical activity, smoking status, economic status and employment status. Linear regression analysis demonstrated that E-DII were significantly associated with certain quality of life criteria, such as physical function, mental health, and vitality ($\beta = 5.58$, 95% CI 0.72, 10.43, $p = 0.024$, $\beta = 16.88$, 95% CI 10.75, 23, $p < 0.0001$ and $\beta = 14.29$, 95% CI 9.48, 20.36, $p < 0.0001$, respectively). No significant associations were observed between EDII and serum level hs-CRP.

Conclusion

It was found that dietary inflammatory potential decreased some quality of life measurements and levels in overweight and obese Iranian women.

Background

Overweight and obesity is excessive fat accumulation, defined as BMI (25-29.9) and BMI $\geq$ 30 respectively, according to WHO definitions [1, 2]. The worldwide prevalence of overweight and obesity in developed and developing countries has increased substantially in recent decades [3]. Overweight and obesity are common in Iran, and are significantly more prevalent among women than men [4]. Accumulating evidence indicates that obesity is closely associated with an increased risk of cardiovascular disease (CVD), hypertension (HTN), type 2 diabetes mellitus (T2DM), hyperlipidemia, strokes, certain cancers, sleep apnea, liver and gall bladder disease, osteoarthritis and poor health quality of life (HQOL) [5].

In addition to medical complications, overweight and obesity is accompanied by a decline in health-related quality of life factors, such as physical functioning, psychosocial functioning, and emotional well-being [6–9]. The results of recent studies shows that overweight and obese people with lower BMI have higher quality of life (QoL) than those with higher BMI scores [10]. The rising prevalence and health-related consequences of overweight and obesity make it a public health concern all over the world [3, 11]. The concept of quality of life is a complex, multifaceted construct that includes various aspects, such as physical health and psychological health [12].

Obesity is typically associated with a chronic state of systemic low-grade inflammation, since adipocytes result in the expression of cytokines such as hs-CRP [13, 14]. Recent studies have shown reliable associations between diet and systemic inflammation. Additionally, it has also been reported that diet can play a major and significant role in quality of life. Previous research has shown that adherence to an anti-inflammatory diet was significantly associated with better health-related quality of life [15, 16]. The energy-adjusted dietary inflammatory index is a validated method developed to characterize dietary inflammatory potential [17]. In view of all the above, it was hypothesized that greater adherence to an anti-inflammatory diet would be associated with lower low-grade inflammation and greater quality of life in overweight and obese patients. To the researchers' knowledge, this is the first study investigating the relationship between energy-adjusted dietary inflammatory index and quality of life.

Methods

Study Design and Participants

The current cross-sectional study was conducted among overweight and obese women who attended health centers in Tehran, Iran, in 2018. A random sample of 280 women was selected from 20 various health centers by a multistage cluster random sampling method. Eligible criteria included body mass index in the range of 25-40 kg/m². Exclusion criteria included: history of cardiovascular disease, hypertension, diabetes mellitus, hepatic or renal disease, alcohol usage, medicine usage other than birth control pills, pregnancy or lactation, following a specific diet or body weight fluctuation over the past 1 year. Informed consent was obtained from all participants. This study was approved by the research council (research project number: 95-03-161-33142, 95-04-161-33893) and ethics committee (research ethics number: IR.TUMS.VCR.REC.1395.1597).

Dietary Assessment

Participants' dietary intake over the past year was assessed using a valid and reliable semi-quantitative food frequency questionnaire (FFQ). This FFQ consists of 147 food items with standard serving sizes, and participants were asked to specify their consumption frequency for each food item on a daily, weekly, monthly or yearly basis. Then, nutrient and energy intakes were computed using NUTRITIONIST IV software (version 7.0; N-Squared Computing, Salem, OR), which was tailored for Iranian foods. For calculating EDII, all nutrient values were adjusted for energy intake using the residual method.

Dietary Inflammatory Index Calculation

To calculate EDII for the participants of this study, the dietary data were first linked to the regionally representative world database, which provided a robust estimate of a mean and standard deviation for each parameter. These then become the multipliers to express an individual's exposure relative to the 'standard global mean' as a z-score. A z-score for each food consumed was calculated by subtracting the 'standard mean' from the actual food parameter value, and divided by its standard deviation. Next, to minimize the effect of 'right skewing', this value was then converted to a centered percentile score, which was then multiplied by the respective food parameter inflammatory effect score to obtain the subject's food parameter-specific EDII score. All of the food-parameter-specific EDII scores were then summed together to create an overall EDII score for every subject in the study [18]. In total, the EDII computed based on this study's FFQ includes data on 29 of the 45 possible food variables composing the EDII: energy, carbohydrate, protein, fat, fiber, cholesterol, trans fat, SFAs, MUFAs, PUFAs, omega-3, omega-6, niacin, thiamin, riboflavin, vitamin B-6, vitamin B-12, iron, magnesium, selenium, zinc, vitamin A, vitamin C, vitamin D, vitamin E, folic acid, b-carotene, caffeine, onion and tea.

Quality of Life Assessment

The SF-36 is a short-form, self-administered quality of life scoring questionnaire. It consists of 36 questions, 35 of which are compressed into eight multi-item scales including: physical functioning (PF), role-physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH). (1) Physical Functioning (PF) is a 10-question scale that captures abilities to deal with the physical requirement of life, such as attending to personal needs, walking, and flexibility. (2) Role-Physical (RP) is a four-item scale that evaluates the extent to which physical capabilities limit activity. (3) Bodily Pain (BP) is a two-item scale that evaluates the perceived amount of pain experienced during the most recent 4 weeks and the extent to which that pain interfered with normal work activities. (4) General Health (GH) is a five-item scale that evaluates general health in terms of personal perception. (5) Vitality (VT) is a four-item scale that evaluates feeling of pep, energy, and fatigue. (6) Social Functioning (SF) is a two item scale that evaluates the extent and amount of time, if any, that physical health or emotional problems interfered with family, friends, and other social interactions during the most recent 4 weeks. (7) Role-Emotional (RE) is a three item scale that evaluates the extent, if any, to which emotional factors interfere with work or other activities. (8) Mental Health (MH) is a five-item scale that evaluates feelings principally of anxiety and depression [19, 20]. The SF-36 also

includes a question self-evaluating health changes in the past year (reported health), which does not belong to the eight dimensions, or the total SF-36 score. Each of these 8 dimensions has a score between 0 (worst health) to 100 (best health). [21-23]

Biochemical Assessment:

Blood samples were collected early in the morning after 12-hour overnight fasting. Serum was separated from whole blood samples and stored at -80°C until the assay Serum hs-CRP levels was measured by an immunoturbidimetric assay with a Pars Azmoon kit (Pars Azmoon Inc. Tehran, Iran).

Anthropometric Assessment:

Anthropometric measures, including body weight, body mass index, waist circumferences and waist-hip ratio, were measured in an overnight fasting state, without shoes, with minimal clothing and by the use of a multi-frequency bioelectrical impedance analyzer In-body 770 scanner (In-body Co., Seoul, Korea). Height was measured with a Seca 206 scale, based on standard protocol.

Assessment of Other Variables:

Physical activity status and socio-demographic information was obtained by questionnaire. Data on physical activity was gathered using the IPAQ questionnaire. Activity was classified as light, medium or heavy levels (IPAQ). The metabolic equation hours per day score (MET-min/week) was then calculated for each subject [24, 25].

Statistical Analyses:

The EDII was analyzed as a dichotomous variable, categorized based on the median value of the EDII (0.05). EDII (as dichotomous) was examined across the following characteristics: age, weight, height, economic status, BMI, waist circumference, waist-hip ratio, energy intake, physical activity, and quality of life measurements, via independent sample T-test analyses. Comparisons of different food group intakes across the EDII quartiles were analyzed through an independent sample T-test. Multivariable linear regression analyses of the continuous EDII score were conducted to determine the association of the EDII with quality of life and hs-CRP levels. Variables were adjusted for the following confounding factors: age, weight, physical activity, smoking, economic status and employment status. The results are reported as percentage change (β) with 95% confidence intervals (95% CI). Statistical analysis was performed using SPSS (version 21) (SPSS Inc., Chicago, USA). Significance was set at a probability of ≤ 0.05 for all tests.

Results

The dietary inflammatory potential scores in this study, as measured by EDII, ranged from -4.14 (most anti-inflammatory score) to 3.89 (most pro-inflammatory score). The mean (SD) age of the participants at recruitment was 36 (8). Table 1 presents participants' characteristics in relation to different categories of dietary inflammatory indices. EDII was categorized into anti-inflammatory ($\text{EDII} \leq 0/05$) and pro-

inflammatory (EDII > 0/06) diets, based on the median value (0.05). When EDII was converted into two groups, significant differences were observed for IPAC ($P < 0.0001$). The hs-CRP level showed no significant change in the higher EDII score group compared to the other group (PC: $4/26 \pm 4/42\%$ vs. $4/07 \pm 4/34\%$; $P = 0.856$).

Significant inverse differences were found between the three dimensions of SF-36, including physical functioning ($P = 0.033$), mental health ($P = 0.021$) and vitality ($P = 0.031$), with anti-inflammatory and pro-inflammatory diet groups. For the other five dimensions, such as general health, role-physical, role emotional, social functioning, bodily pain and health transition, decreasing trends were observed across EDII categories, but these relationships were not significant (Table 2).

Table 3 shows the distribution of 11 food groups: grains, refined grains, dairy products, beans, vegetables, fruits, red meat, processed meat, white meat, nut/olive group and sweet/fat group across the EDII groups. The results showed that servings of vegetables and beans ($P < 0.0001$) decreased significantly in the higher dietary inflammatory index group, whereas servings of sweet/fat group ($P < 0.0001$) increased significantly in this group.

A direct association between EDII and physical functioning levels was observed after adjustment for potential confounders, such as age, weight, smoking, economic status and employment status ($P = 0.024$) (Table 4).

Multivariable linear regression analysis with adjustments for potential confounders demonstrated that EDII were significantly associated with mental health and vitality ($\beta = 5.58$, 95% CI 0.72, 10.43, $p = 0.024$ (Table 2), $\beta = 16.88$, 95% CI 10.75, 23, $p < 0.0001$ (Table 5) and $\beta = 14.29$, 95% CI 9.48, 20.36, $p < 0.0001$ (Table 6)), respectively.

Discussion:

It is important to note that this is the first study to examine the association between dietary inflammatory potential, quality of life and inflammation levels among women. This cross-sectional study of Iranian women showed evidence of a positive association between higher (i.e. more pro-inflammatory) EDII scores with lower quality of life in certain measurements, such as physical functioning, mental health and vitality. These findings emphasize the importance of addressing overall dietary quality in future community- or population-based programs or policies to prevent chronic disease.

Some prior research has shown that inflammatory diet plays an important role in psychological health. Almudena Sánchez-Villegas et al. also determined that a pro-inflammatory diet was associated with a significantly higher risk of depression in a Mediterranean population, particularly in older subjects [26]. Tasnime N. Akbaraly et al. found that a pro-inflammatory diet was associated with recurrent depression in women, which seems not to be driven by circulating inflammatory markers [27]. There is considerable evidence that has suggested a better quality of diet or anti-inflammatory diet is associated with better quality of life and better mental health. Ujué Fresán et al. have found that a Mediterranean diet was

associated with reduced depression risks [28]. A recent study in Australia demonstrated that better dietary quality in older adults was related with better health-related quality of life and emotional wellbeing in women [29]. The current findings are supported by an Australian study which reported that adherence to an MD pattern is associated with better mental and physical health, and that this association is particularly stronger in terms of mental health than physical health [30]. A possible mechanism seems to be related to the fact that an anti-inflammatory diet is rich in nutrients such as vitamins, minerals, antioxidants, and fiber, which have beneficial health effects that have been widely demonstrated.

The results revealed no relationship between EDII and hs-CRP levels in women. To the best of the researchers' knowledge, previous studies of dietary inflammatory indices and serum hs-CRP levels are generally consistent with the findings of the present study. A number of other studies have suggested that a pro-inflammatory diet is associated with higher levels of inflammatory markers. Previous studies have shown that DII was associated with an increase in the odds of elevated hs-CRP levels (.3 mg/l) [31]. Another study in the USA demonstrated that higher DII scores were associated with inflammatory biomarkers including IL-6, TNF- α and hs-CRP [32]. In the Asklepios study, no significant associations were observed between DII and inflammatory markers CRP and fibrinogen, but significant positive associations between DII and inflammatory markers IL-6 and homocysteine were observed [33].

Conclusion:

The most interesting finding of this study is that the multivariable linear regression analysis has revealed that more anti-inflammatory diets are significantly associated with higher physical function, mental health and vitality in overweight and obese women. Thus, encouraging the intake of more anti-inflammatory dietary factors, such as plant-based foods rich in fiber and phytochemicals, and reducing intake of pro-inflammatory factors, such as fried foods or processed foods rich in saturated fat, may be a beneficial strategy for better physical and mental health.

The present study had some limitations that should be considered. First of all, the use of self-reported food-frequency questionnaires (FFQ) is known to contain a certain degree of measurement error, which might affect results. Moreover, an FFQ consisting of 29 instead of 45 food parameters was used for calculating EDII. The small sample size is another limitation, and data from larger sample size studies are more credible. In addition, casual relationship between energy-adjusted dietary inflammatory index, inflammatory markers, and quality of life cannot be inferred using retrospective observational studies; conducting prospective studies is thus highly recommended.

Abbreviations

BMI: Body mass index, CVD: Cardiovascular disease, C-reactive protein, EDII: Energy-Adjusted dietary inflammatory index, ELISA: Enzyme-linked immunosorbent assay, FFQ: Food frequency questionnaire, HQOL: Health quality of life, HTN: Hypertension, Hs-CRP: High-sensitivity C-reactive protein, IL-6: Interleukin-6, IPAQ: International Physical Activity Questionnaires, MUFA: [Monounsaturated fatty acids](#)

,METs: Metabolic Equivalent Tasks, PUFA: Polyunsaturated fatty acids , QOL: Quality of life, SFA: Saturated fatty acids, T2DM: Type 2 diabetes mellitus , TNF α : Tumor necrosis factor- α , WHO: World Health Organization

Declarations

Authors' contributions

The project was designed and implemented by NGH and KhM. Data were analyzed and interpreted NGH, HA, AM, SY, SAK and HI prepared the manuscript. KhM, supervised overall project. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The data that support the findings of this study are available from Khadijeh Mirzaei but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Khadijeh Mirzaei

Consent for publication

Each participant was completely informed about the study protocol and provided a written and informed consent form before taking part in the study.

Ethics approval and consent to participate

The study protocol has approved by the ethics committee of Endocrinology and Metabolism Research Center of Tehran University of Medical Sciences (TUMS) with the following identification: IR.TUMS.VCR.REC.1395.1597.

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Tables

Table 1. Participant Characteristics between EDII Groups

Participant Characteristics	EDII Groups	Mean	Std. Deviation	P value
Age(year)	<= .05	37.60	7.58	0.105
	.06+	35.03	8.48	
Weight(kg)	<= .05	81.09	12.56	0.317
	.06+	80.61	12.09	
Height(cm)	<= .05	161.25	6.24	0.217
	.06+	161.33	5.75	
BMI(kg/m²)	<= .05	30.94	3.99	0.130
	.06+	30.52	3.56	
Waist Circumference(cm)	<= .05	99.25	10.24	0.391
	.06+	98.97	9.89	
Waist-Hip Ratio	<= .05	.93	.05	0.651
	.06+	.93	.05	
Energy Intake(kcal)	<= .05	2588.82	707.15	0.140
	.06+	2658.21	790.42	
IPAC(MET-min/week)	<= .05	1162.45	1322.88	<0.0001
	.06+	773.24	692.04	
Hs-CRP(mg/L)	<= .05	4.26	4.42	0.856
	.06+	4.07	4.34	
SF Total	<= .05	77.32	13.43	0.715
	.06+	72.11	12.80	

n= 280

Data are presented as mean ± standard deviation.

Nutrients intake adjusted for energy intake before calculating EDII

DII values were categorized according to the median

(DII ≤ 0/05: Anti-inflammatory diet, DII > 0/06: pro-inflammatory diet)

Independent sample *t* test was used for comparison of continuous variables between DII categories

Table 2. Quality of Life Items by Level of EDII groups

SF-36 Items	DII Groups	Mean	Std. Deviation	P value
General Health	<= .05	68.47	18.88	0.082
	.06+	66.92	16.77	
Physical Functioning	<= .05	84.37	16.65	0.033
	.06+	79.16	22.33	
Role Physical	<= .05	91.24	28.37	0.094
	.06+	88.15	32.44	
Role Emotional	<= .05	86.78	33.89	0.073
	.06+	82.89	37.71	
Social Functioning	<= .05	73.65	22.71	0.968
	.06+	70.76	23.53	
Bodily Pain	<= .05	62.31	21.02	0.871
	.06+	63.09	20.24	
Vitality	<= .05	76.37	18.35	0.031
	.06+	60	22.28	
Mental Health	<= .05	82.33	20.82	0.021
	.06+	66.28	24.52	
Health Transition Item	<= .05	51.82	29.34	0.056
	.06+	46.67	25.70	
SF-36 -TOTAL	<= .05	77.32	13.43	0.715
	.06+	72.11	12.80	

n=280

Data are presented as mean $\pm$ standard deviation.

Nutrients intake adjusted for energy intake before calculating EDII

EDII values were categorized according to the median.

(Anti-inflammatory diet: EDII $\leq$ 0/05, pro-inflammatory diet: EDII > 0/06)

Independent sample *t* test was used for comparison of continuous quality of life measures between EDII categories

Table 3. Relationships between Servings of Food Groups across EDII Groups

Food Groups(g/day)	EDII Groups	Mean	Std. Deviation	P value
Grains	<= .05	458.59	218.60	0.749
	.06+	507.98	242.73	
Refined Grains	<= .05	385.37	220.20	0.274
	.06+	479.92	243.59	
Dairy Products	<= .05	390.78	217.44	0.272
	.06+	351.84	270.79	
Beans	<= .05	57.75	49.82	<0.0001
	.06+	41.01	26.91	
Vegetables	<= .05	535.37	250.44	<0.0001
	.06+	292.86	193.06	
Fruits	<= .05	653.14	354.93	0.060
	.06+	454.64	326.29	
Red Meat	<= .05	46.45	24.31	0.995
	.06+	42.80	25.40	
Processed Meat	<= .05	4.08	10.48	0.862
	.06+	5.65	7.92	
White Meat	<= .05	50.27	40.06	0.987
	.06+	43.71	51.31	
Nut.Olive	<= .05	13.87	11.52	0.116
	.06+	9.94	10.93	
Sweet. Fat	<= .05	80.27	50.13	<0.0001
	.06+	126.26	111.59	

n=280

Data are presented as mean $\pm$ standard deviation.

Nutrients intake adjusted for energy intake before calculating EDII

EDII values were categorized according to the median.

(EDII $\leq$ 0/05: Anti-inflammatory diet, EDII $>$ 0/06: Pro-inflammatory diet)

Independent sample *t* test was used for comparison of food group's intake between EDII categories

Table 4. Relationship between EDII and physical functioning

Variables	B	95% (CI)	P value
Anti-inflammatory diet	5.58	(0.72,10.43)	0.024
Pro-inflammatory diet	.Ref		.Ref
Age (years)	0.07	(-0.24, 0.38)	0.653
Weight (kg)	0.01	(-0.18,0.20)	0.919
Smoking (Smoker)	-3.52	(-14.02,6.98)	0.511
Smoking (Non-smoker)	.Ref		.Ref
Economic status (Poor)	-0.27	(-7.13,6.59)	0.938
Economic status (Medium)	3.86	(-2.04,9.76)	0.199
Economic status (Good)	.Ref		.Ref
Job status (Unemployed)	-1.71	(-3.52,6.93)	0.522
Job status (Employed)	.Ref		.Ref

n=280

(Anti-inflammatory diet: EDII $\leq$ 0/05, pro-inflammatory diet: EDII $>$ 0/06)

Multivariable linear regression test was used to investigate the relationship between EDII and physical functioning

Table 5. Relationships between EDII and Mental Health

Variables	B	95% (CI)	P value
Anti-Inflammatory Diet	16.88	(10.75,23.00)	<0.0001
Pro-Inflammatory Diet	.Ref		.Ref
Age (years)	-.14	(-0.52,0.25)	.478
Weight (kg)	.05	(-0.21,0.31)	.704
Physical Activity (MET-min/week)	-2.12	(-5.12,0.87)	.164
Smoking (Smoker)	6.59	(-6.82,20.01)	.335
Smoking (Non-smoker)	.Ref		.Ref
Economic Status (Poor)	-1.13	(-9.62,7.37)	.795
Economic Status (Medium)	-.98	(-8.24,6.28)	.791
Economic Status (Good)	.Ref		.Ref
Job Status (Unemployed)	4.37	(-2.09,10.82)	.185
Job Status (Employed)	.Ref		.Ref

n=280

(Anti-inflammatory diet: EDII $\leq$ 0/05, pro-inflammatory diet: EDII $>$ 0/06)

Multivariable linear regression test was used to investigate the relationship between EDII and mental health

Table 6. Relationships between EDII and Vitality

Variables	β	95% (CI)	P value
Anti-Inflammatory Diet	14.92	(9.48,20.36)	<0.0001
Pro-Inflammatory Diet	.Ref		.Ref
Age (years)	0.04	(-0.30,0.37)	0.837
Weight (kg)	0.01	(-0.22,0.23)	0.961
Physical Activity (MET-min/week)	2.23	(-0.43,4.89)	0.100
Smoking (Smoker)	8.02	(-3.49,19.54)	0.172
Smoking (Non-smoker)	.Ref		.Ref
Economic Status)Poor)	-1.27	(-8.84,6.29)	0.742
Economic Status (Medium)	0.39	(-6.04,6.82)	0.906
Economic Status (Good)	.Ref		.Ref
Job status (Unemployed)	2.56	(-3.11,8.22)	0.377
Job status (Employed)	.Ref		.Ref

n=280

(Anti-inflammatory diet: EDII $\leq$ 0/05, pro-inflammatory diet: EDII > 0/06)

Multivariable linear regression test was used to investigate the relationship between EDII and vitality