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Research Article

Healthy Eating Index and Semen Parameters in Iranian Infertile Men

Farahnaz Haeri[1], Omidreza Sadrmanesh[4], Kimia Leilami[2], Mehran Nouri[2], and Reza Ghiasvand[3]*

[1]*Department of Community Nutrition, Isfahan University of Medical Sciences, Iran*
[2]*Department of Nutrition, Shiraz University of Medical Sciences, Iran*
[3]*Food security research center, Isfahan University of Medical Sciences, Iran*
[4]*Department of Nutrition, Kerman University of Medical Sciences, Iran*

***Corresponding author**
Reza Ghiasvand, Food security research center Isfahan, University of Medical Sciences Isfaha, PO Box, 81745, Iran, Tel: 983137923153 Fax: 983136682509

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Keywords
- Healthy eating index
- Male infertility
- Sperm parameters

Abstract

Background: Infertility had an increasing trend between couples in Iran. Some epidemiological studies have reported a relationship between infertility and lifestyle patterns including dietary habits. Our objective was to identify the relation between Healthy eating index and sperm parameters in Iranian infertile men.

Methods: This cross-sectional was performed on 400 newly diagnosed infertile men in Yazd Reproductive Sciences Institute from July to December 2019. Men were recruited when their infertility was confirmed by the expert andrologist based on WHO criteria. They delivered a semen sample and answered a 168 items semi quantitative food frequency questionnaire (FFQ). All data were analyzed using SPSS V. 22 software. P-value less than 0.5 considered as significant.

Results: There was significant association between sperm density and HEI score tertile in crude model but after adjustment for potential confounders there was not any association. Participants in highest tertile had a higher risk of density and lower risk of motility in crude model (OR =1.69; 95% CI: 1.00, 2.88; P=0.05 and OR=1.31; 95% CI: 0.78, 2.21; P=0.29) and risk of density (OR=1.15; 95% CI: 0.65, 2.03; P=0.63 and OR=1.31; 95% CI: 0.71, 2.40; P=0.38) and motility decrease in adjusted models (OR=0.86; 95% CI: 0.49, 1.52; P=0.59 and OR=0.92; 95% CI: 0.50, 1.67; P=0.74).

Conclusions: We concluded that adherence to HEI principles can have a positive effect on men's fertility. However, more research is needed to confirm these relations and provide the evidence needed to exert these findings into clinical practice.

INTRODUCTION

Over the last years, there has been an increasing concern about a global decline in men's fertility [1]. Male fertility is a key aspect of reproductive health and infertility is identified as a global public health issue by the World Health Organization (WHO). Infertility is defined by the WHO and International Committee for Monitoring Assisted Reproductive Technology (ICMART) as the 'failure to achieve a pregnancy after 12 months or more of constantly unprotected sexual intercourse. The prevalence of infertility among couples according to various sources, is from 8% to 25% [2-4]. Specifically, some evidence indicates that sperm quality has decreased over the last years [1]. several reasons have been recommended for semen quality declination [5-7]. Recent studies have identified a link between lifestyle patterns and infertility [8,9]. Rapid changes in nutritional behavior, such as the increased prevalence of unhealthy dietary patterns, characterized by higher intake of trans fatty acids, saturated fat, and sodium and lower consumption of antioxidant-rich foods, such as fruits and vegetables have impacted reproductive health. A compound of food fundamental consolidated into the appropriate dietary pattern may have more favoring effects in prevention or control of the disease. Several approaches have been suggested for evaluating the dietary patterns such as healthy eating index (HEI). This index was designed to evaluate diet quality in different societies with different dietary patterns. The results of previous studies on the relationship between dietary patterns with male infertility are limited. Also, there is no information about the association of HEI-2010 score and infertility among Iranian male.

The aim of this study was to determine the relationship between HEI-2010 score and semen quality and quantity among Iranian infertile men.

MATERIALS AND METHODS

Study population

This cross-sectional study was conducted on 400 infertile men that referred to Yazd Reproduction Research Institute from July to December 2019. Inclusion criteria include age between 20 to 55 years, progressive motility < 32%, normal morphology <4%, semen volume < 1.5 ml and sperm count < 15 million per milliliter [10]. Also, exclusion criteria containing history of testicular atrophy, urinary infection, hypospadias, genital diseases, androgens, anticoagulants, cytotoxic drugs or immunosuppressant, metabolic diseases such as cardiovascular disease, diabetes, cancer, osteoporosis or renal disease, ejaculatory disorder, stenosis, varicocele, use of supplements, adherence to specific diets, no-response to more than 35 items of food frequency questionnaire and underreporting and over-reporting of energy intake (more than 4,200 and less than 800) [11,12] Informed consent was obtained from all subjects involved in the study and dietary information was collected by trained interviewer.

Physical examination and lifestyle variable

Data regarding physical activity level were assessed using a validated and reliable questionnaire (International Physical Activity Questionnaire) [13]. This questionnaire provides data about levels of strenuous activity, moderate activity, walking and inactivity. For all that, we identified the data regarding duration (minutes per day) and frequency (days per week) for all type of activities. Socioeconomic status (SES) of the subjects was concluded based on variables, such as education (number of years of study), home situation (landlord-tenant), has car (yes-no), number of overseas trips, washing machine and dishwasher (yes-no), individual occupation.

Anthropometric data

Anthropometric information include Waist to hip ratio (WHR) and Body mass index (BMI), determined based on standard protocol of World Health Organization (WHO) [14], under special condition, without shoes and wearing minimal, to the nearest 0.1kg, by using Falcon scales (Seca, Hamburg, Germany). Also, all measurements were archived with an accuracy of 0.1 cm. Waist circumference (WC) was measured midpoint between the last rib and the iliac crest (umbilical level) and hip circumference (HC) was measured since the widest part of buttocks. BMI and WHR were calculated according to this formula: BMI: weight (kg)/ height (m2) and WC: (cm)/HC (cm), respectively [14].

Dietary assessment

Usual dietary intake was identified by using a 168 items semi quantitative Food Frequency Questionnaire (FFQ). The validity of FFQ is confirmed in Iran [15]. This form was designed according to frequency of consumption of the common foods of one's country during the past 12 months (number of times consumed daily, weekly, monthly, and annually). FFQ was filled out by a trained nutritionist, by interviewing. The dietary fatty acids and minerals intake were determined by computer program from the food- frequency data, using standard portion sizes and the mineral contents given in the food composition tables.

Semen analysis

Semen samples were taken from participants following 3 days of abstinence. After providing sample, the container kept in Incubator for 30 min to liquefied. samples were kept in sterile containers at 37 ° C for 30 minutes, and were then assessed and analyzed according to the WHO Fifth Edition Laboratory Guidelines [16]. Four parameters of semen and sperm including semen volume, sperm concentration, normal sperm morphology and sperm motility were measured.

Statistical methods

In this study, participants were categorized based on tertiles of Healthy Eating Index (HEI). To access the normality of the data, Kolmogorove-Smirnov test was used. To compare continuous and categorical variables across tertiles of HEI, one-way analysis of variance (ANOVA) and chi-squared test was used. To assess the relation between HEI and odds of sperm parameters, two different multivariable logistic regressions was used (crude and adjusted model). Age and energy intake controlled in the first adjusted model, and BMI, marriage time, educational status, physical activity, alcohol and smoking history were added in the second adjusted model.

The latest version of HEI index designed in 2015 according to 2015–2020 dietary guidelines for Americans [17]. HEI-2015 scores calculated with 13 components. The maximum point for each component was 5 or 10. The highest consumption of total fruits, whole fruits, total vegetables, greens and beans, total protein foods, seafood and plant proteins scored 5 and for whole grains, dairy and fatty acids ((Polyunsaturated fatty acid + Monounsaturated fatty acids)/Saturated fatty acid) scored 10. For example, the lowest consumption of these 9 items scored 0, whereas the highest consumption scored 5 or 10. The other 4 components (including refined grains, sodium, added sugars and saturated fats) were scored in reverse, which means that, the lowest consumption of these items was scored as 10 and the highest was scored as 0. By summing the scores of all 13 components, total HEI score was calculated and the participants were categorized into tertile based on their scores.

Statistical analyses were carried out using SPSS for Windows software (version 20.0), SPSS Inc, and Chicago IL. P-value < 0.05 was considered statistically significant.

RESULTS

Table 1 illustrates the baseline characteristics of participants through tertiles of HEI. The mean age, body mass index and waist circumference of infertile men were 33.65 years, 26.16 kg/m^2, 93.76 cm, respectively. There was a significant change between tertiles of HEI with BMI, waist and hip circumferences. Waist circumference was higher in last tertile of HEI score and hip circumference was higher in the first tertile therefore, WHR (waist to hip ratio) was higher in the last tertile. There was a significant relationship between physical activity level and near living areas to fields with HEI.

Table 2 displays the participants' energy-adjusted dietary

Table 1. Basic characteristics of participants across the tertiles of HEI scores.

Variable	HEI			
	T1 (N=136)	T2 (N=131)	T3 (N=130)	P-value
Age (year)	33.67±7.07	33.59±6.54	33.71±5.58	0.98
Weight (kg)	76.66±14.94	80.89±20.17	81.11±19.60	0.08
Height (cm)	175.43±8.48	27.33±5.36	26.17±5.51	<0.001
Body mass index (kg/m^2)	25.02±4.88	27.33±5.36	26.17±5.51	0.002
Waist circumference (cm)	89.09±17.58	95.28±18.82	97.13±22.76	0.003
Hip circumference (cm)	96.84±17.87	102.09±21.84	92.13±24.11	0.001
WHR	0.92±0.08	0.94±0.09	1.06±0.11	<0.001
Education (year)	10.32±3.47	10.22±4.44	10.97±4.46	0.28
Physical activity level (n (%)) Inactive Minimal activity High activity	27 (19.85) 57 (41.91) 52 (38.24)	43 (32.82) 49 (37.40) 39 (29.78)	66 (50.77) 48 (36.92) 16 (12.31)	<0.001
Smoking history (n (%)) Yes No	55 (40.44) 81 (59.56)	57 (43.51) 74 (56.49)	59 (45.39) 71 (54.61)	0.71
Near living areas to fields (n (%)) Yes No	74 (54.41) 62 (45.59)	52 (39.69) 79 (60.31)	23 (17.69) 107 (82.31)	<0.001

HEI, healthy eating index; WHR, waist to hip ratio. Values are mean (SD) for continuous and percentage for categorical variables. Using one-way ANOVA for continuous and Chi-square test for categorical variables.

Table 2. Dietary intakes of participants across the tertiles of HEI scores

Variable	HEI			
	T1 (N=136)	T2 (N=131)	T3 (N=130)	P-value
Nutrient items				
Energy (kcal/d)	2724.33±677.99	3095.62±601.07	3165.05±582.60	<0.001
Carbohydrate (g/d)	596.58±244.35	726.52±372.39	540.90±261.26	<0.001
Protein (g/d)	149.67±60.81	176.78±71.95	132.08±61.07	<0.001
Fat (g/d)	152.22±60.81	193.13±96.65	118.25±53.68	<0.001
SFA (g/d)	49.40±23.79	58.56±32.44	32.42±16.39	<0.001
MUFA (g/d)	48.93±19.57	62.53±31.49	40.34±15.67	<0.001
PUFA (g/d)	30.84±12.27	41.84±30.70	28.29±15.98	<0.001
Cholesterol (mg/d)	575.00±429.48	734.09±493.12	337.14±189.17	<0.001
Vitamin A (RAE/d)	1990.55±3107.12	2644.46±3798.56	771.79±1026.00	<0.001
Vitamin E (mg/d)	20.91±6.44	31.01±25.97	20.56±4.59	<0.001
Vitamin B_6 (mg/d)	3.17±1.26	3.45±1.48	2.69±1.10	<0.001
Vitamin B_9 (μg/d)	921.13±383.88	1114.12±525.87	838.99±460.87	<0.001
Vitamin B_{12} (μg/d)	20.15±31.34	26.59±38.69	7.88±10.39	<0.001
Vitamin C (mg/d)	163.97±89.04	184.25±139.58	141.01±87.32	<0.001
Calcium (mg/d)	1750.13±991.44	2018.51±937.35	1251.55±648.42	<0.001
Magnesium (mg/d)	728.35±315.69	842.36±355.81	699.56±335.77	0.001
Selenium (mg/d)	244.61±131.48	280.91±135.87	229.26±130.77	0.005
Zinc (mg/d)	23.04±10.39	16.11±11.45	20.65±10.58	<0.001
Iron (mg/d)	32.76±15.34	39.66±19.22	30.37±15.57	<0.001
Foods items				
Whole grains (g/d)	73.19±139.65	140.10±186.86	211.85±245.67	<0.001
Refined grains (g/d)	716.41±368.30	693.83±396.47	531.64±369.62	<0.001
Total fruits (g/d)	360.44±232.16	400.56±316.73	383.74±218.27	0.42
Total vegetables (g/d)	361.70±345.12	441.92±329.94	294.71±187.29	<0.001
Legumes (g/d)	99.02±98.10	115.47±107.43	101.27±130.06	0.42
Nuts (g/d)	39.96±58.52	48.74±69.06	37.72±79.25	0.39
Dairy (g/d)	677.28±640.04	672.95±437.33	297.67±231.54	<0.001
Total protein foods (g/d)	320.79±182.34	373.66±204.30	291.29±201.32	0.003
Added sugars (g/d)	277.65±251.08	482.37±809.89	115.38±128.65	<0.001

SFA, saturated fatty acid; PUFA: polyunsaturated fatty acid; MUFA; monounsaturated fatty acid. Values are mean ± SE. All values are adjusted for energy intake using ANCOVA.

nutrient and food items intakes by tertiles of HEI. Participants in the last tertile of HEI had higher intake of energy and whole grains but lower intake of carbohydrate, protein, fat, SFA, MUFA, PUFA, cholesterol, viitamin A, E, B_6, B_9, B_{12}, C, calcium, magnesium, selenium, zinc, iron, refined grains, total vegetables, dairy, total protein foods and added sugars. Intakes of total fruits, legume and nuts did not differ in HEI score tertiles.

Table 3 displays the mean and standard deviation (SD) of sperm parameters in crude and modified models for each tertile of HEI. For the HEI, participants in the highest tertile had not difference mean of sperm parameters with those in the lowest tertile in the crude model. In addition, after adjustment for potential covariates such as age, energy intake, BMI, physical activity, educational and smoking history, difference was not significant except in volume parameter.

Table 4 displays the multivariable-adjusted odds ratio (OR) and 95% confidence intervals (CIs) for sperm parameters throughout tertiles of HEI. There was significant association

Table 3. Mean sperm parameters across tertiles of HEI scores.

Variable	HEI			
	T1 (N=136)	T2 (N=131)	T3 (N=130)	P-value
Volume (ml)				
Model I[a]	3.76±1.88[d]	3.59±1.62	3.39±1.73	0.22
Model II[b]	3.76±1.88	3.59±1.62	3.39±1.73	0.06
Model III[c]	3.76±1.88	3.59±1.62	3.39±1.73	0.02
Density (×10^6/ml)				
Model I[a]	44.78±33.55	41.38±35.21	37.29±31.97	0.19
Model II[b]	44.78±33.55	41.38±35.21	37.29±31.97	0.72
Model III[c]	44.78±33.55	41.38±35.21	37.29±31.97	0.49
Total motility (%)				
Model I[a]	42.94±15.30	41.33±15.30	39.73±18.03	0.27
Model II[b]	42.94±15.30	41.33±15.30	39.73±18.03	0.53
Model III[c]	42.94±15.30	41.33±15.30	39.73±18.03	0.55

[a] Crude. [b] Adjusted for age and energy intake. [c] Additionally adjusted for BMI, physical activity, educational and smoking history. [d] These values are mean (SE).
[e] Using ANCOVA.

Table 4. Crude and multivariable-adjusted odds ratios and 95% CIs for sperm parameters rs across tertiles of HEI scores.

Variable	HEI			
	T1 (N=136)	T2 (N=131)	T3 (N=130)	P-value
Volume (ml)				
Model I[a]	1.00	0.87 (0.45, 1.71)[d]	1.29 (0.69, 2.42)	0.41
Model II[b]	1.00	0.95 (0.47, 1.88)	1.42 (0.73, 2.74)	0.28
Model III[c]	1.00	1.05 (0.52, 2.14)	1.69 (0.82, 3.47)	0.18
Density (×10^6/ml)				
Model I[a]	1.00	1.67 (0.99, 2.84)	1.69 (1.00, 2.88)	0.05
Model II[b]	1.00	1.21 (0.69, 2.13)	1.15 (0.65, 2.03)	0.63
Model III[c]	1.00	1.20 (0.67, 2.16)	1.31 (0.71, 2.40)	0.38
Total motility (%)				
Model I[a]	1.00	1.58 (0.95, 2.64)	1.31 (0.78, 2.21)	0.29
Model II[b]	1.00	1.13 (0.65, 1.95)	0.86 (0.49, 1.52)	0.59
Model III[c]	1.00	1.19 (0.67, 2.09)	0.92 (0.50, 1.67)	0.74

[a] Crude. [b] Adjusted for age and energy intake. [c] Additionally adjusted for BMI, physical activity, educational and smoking history. [d] These values are odd ratio (95% CIs).
[e] Obtained from logistic regression.

between sperm density and HEI score tertile in crude model but after adjustment for potential confounders including age, energy intake, BMI, physical activity, educational and smoking history there was not any association. Participants in highest tertile had a higher risk of density and lower risk of motility in crude model (OR =1.69; 95% CI: 1.00, 2.88; P=0.05 and OR=1.31; 95% CI: 0.78, 2.21; P=0.29) and risk of density (OR=1.15; 95% CI: 0.65, 2.03; P=0.63 and OR=1.31; 95% CI: 0.71, 2.40; P=0.38) and motility decrease in adjusted models (OR=0.86; 95% CI: 0.49, 1.52; P=0.59 and OR=0.92; 95% CI: 0.50, 1.67; P=0.74).

DISCUSSION

This cross-sectional study demonstrated that, in the third tertile compared to first tertile of HEI, risk of density and motility of sperms increased, and in fact adherence to HEI principles can have a positive effect on men's fertility. But according to our result higher scores of HEI can be related to lower volume of sperm.

So far, most studies investigated the effect of a specific food or small group of foods on sperm indexes, and there is lack of priori studies on this issue. While priori studies are highly reliable methods and are based on acceptable standards, also in other topics, such as anti-inflammatory and antioxidant effects [18,19], prevention of chronic diseases and even mortality, there are proven results [20,21], but still effect of dietary pattern on reproductivity is unknown and the aim of current study was to evaluate the potential relationship between HEI score and reproductive ability in men.

The results of previous studies were similar to our study, Efrat et al reported that higher quartiles of HEI was connected with higher sperm concentration and motility, also they claimed that more adherence to Alternative Healthy Eating Index (AHEI) could have positive effect on sperm count, concentration, normal morphology and motility [22]. Cutillas Tolin et al., only showed that men with higher scores of AHEI had lower abstinence time compared to others [23]. In general, review and meta-analysis studies have concluded that men with healthy diet patterns (more consumption of total grains, fruits, vegetables, chicken and fish and less intake of fat and red meat) have better seminal quality [24,25]. In a cross-sectional study that evaluated food patterns of 188 young men, reported that more consumption of fish, whole grain, fruits and vegetables had positive correlation with sperm motility [26].

Several possible mechanisms can contribute to the positive effects of healthy dietary patterns on male fertility, first consumption of fruits and vegetables due to high antioxidant content can have a protective effect on the quality of sperm [27,28]. Even, receiving adequate antioxidants through regimen or supplements is considered as one method of infertility treatment, and according to various studies, between 11% and 41% increase the pregnancy rate [29]. Second, less intake of refined cereals, fats and processed meat is associated with better semen quality [8,30]. The third and maybe most probable cause is, the fact that adherence healthy food patterns is associated with a lower risk of chronic diseases, for example, Fung T et al in their study proved that high AHEI scores is connected with less risk of chronic diseases such as Diabetes and cardiovascular disease (CVD) [31,32]. Meanwhile, obesity and overweight are one of the most important chronic diseases that have a reverse relationship with physical and molecular characteristics of sperms [33]. In addition, excess adipose tissue can cause changes in the level of hormones and reduces testosterone conversion to estradiol, which leads to hypogonadism and inhibition of reproductive axes [34].

Among our limitations in this study was, due to the type of design that was cross-sectional observational study, we cannot prove a causal relationship between the diet and fertility in men. In order to evaluate the diet of participants, the FFQ questionnaire specialized for Iranian populations has been used, although it is among the most reliable methods, but depends on the personal memory of the individual and causes some errors in their report. And we used one semen sample to evaluate sperm indices, which reported that it's an appropriate and sufficient tool in epidemiological studies. The most important strength point of recent study is to investigate new and principal issue, and applied dietary pattern that better represent the food intake of individuals. We also had access to appropriate infertile men as our population that was carefully examined in terms of including and excluding criteria to decrease selection bias and the results were also adjusted for confounders because of more accuracy of data.

DECLARATIONS

Ethical Approval and Consent to participate

The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences code IR.MUI.RESEARC H.REC.1398.264.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authorship

F.H, R.Gh designed the study and developed the protocol. F.H, R.Gh, KL, OS were involved in developing the search string and conducted the literature search. MN,OS conducted primary and secondary screening. FH, R.Gh wrote the first draft of the paper. All authors critically revised all drafts of the paper and approved the final version.

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