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Research Article

Dietary Fatty Acids and Minerals Intake are related to Sperm Parameters in Men Referring to an Iranian Reproductive Sciences Institute: A Cross-Sectional Study

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Abstract

Background & Aims: 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 sperm parameters and dietary fatty acid and mineral intake among 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: We found a positive association between Poly-unsaturated fatty acid intake, total motility and normal morphology (P-value=0.03). Also, there was a significant negative association between second quartile of sodium and calcium intake and sperm volume (P trend: 0.04), compared with first quartile.

Conclusions: We concluded that dietary of Poly-unsaturated fatty acid intake, sodium and calcium intake are related to sperm morphology, volume and total motility in Iranian infertile men. However, more research is needed to confirm these relations and provide the evidence needed to exert these findings into clinical practice.

INTRODUCTION

In recent years, the growing prevalence of infertility has been a major concern among young couples [1]. Based on recent studies, one in six couples suffer from infertility problems, and half of all infertility cases are related to men [2]. Studies have shown conflicting results in reducing the quantity and quality of sperm in young men [3,4]. Researchers declared that the decline in sperm quality is majorly associated to environmental factors. Also, among the other factors influencing infertility, smoking and alcohol consumption, drug abuse, obesity and stress are the most important [5,6].Diet is also one of the factors affecting the quality of sperm. Previous studies have explained that certain dietary compounds, including antioxidants in fruits and vegetables or dietary fats, can affect sperm quality in men [7,8]. Literature have reported healthy diet which includes plenty of fish, vegetables and whole grains, leads to more active sperm production, while a diet containing trans fatty acids may reduce sperm count [9,10].

Fats are considered an important part of our diet. Cholesterol as one type of dietary fat, plays an important role in the structure of mammalian membranes. The sperm cell membrane is affected by the type of fats, which is consumed in the diet [11]. Also, it is rational that increasing the intake of saturated fatty acids and Tran's fatty acids can affect sperm quality through increasing inflammation in the body [12]. Prior studies have indicated a significant link between the consumption of some dietary minerals such as iron and zinc with semen quality [13,14].

Even though studies in recent years have examined the effect of dietary components on sperm quality, the results of studies are challenging. Therefore, the present study was designed to investigate the relationship between sperm quality and quantity parameters and fat and dietary minerals.

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 [15]. 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) [16,17]. Informed consent was obtained from all subjects involved in the study and dietary information was collected by trained interviewer.

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

Physical examination and lifestyle variable

Data regarding physical activity level were assessed using a validated and reliable questionnaire (International Physical Activity Questionnaire) [18]. 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)(19), 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 [19].

Dietary assessment

Usual dietary intake was identified by using a 168 items semiquantitative Food Frequency Questionnaire (FFQ). The validity of FFQ is confirmed in Iran [20]. 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 [21]. Four parameters of semen and sperm including semen volume, sperm concentration, normal sperm morphology and sperm motility were measured.

STATISTICAL METHODS

Sperm volume, density, total motility and morphology were outcome variables. Average fatty acids and minerals intake were exposure variables. Based on the amount of intake, fatty acids and minerals were divided into four groups. Lowest intake of each micronutrient quartile was considered as the reference group. In order to examine the association between each micronutrient and sperm parameters. Linear regression was used for crude and adjusted model. The adjusted model included age, BMI, smoking status physical activity and energy intake. Covariance test (ANCOVA) used to calculated micronutrient mean in each quartile. For the crude and adjusted model, beta and confident interval 95% (CI 95%) were calculated. Also, for statistical analyses, STATA 14 (Stata Corp, College Station, Texas, USA) was used. P-value less than 0.5 considered as significant.

RESULTS

Baseline characteristic of participants

The mean age of our study population was 33.66 years [standard deviation (SD): 6.4] with a BMI of 26.12 (SD: 5.33). The mean percentage of motile sperm was 41.05% (SD: 16.58%), the mean value for morphologically normal sperm was 2.59% (SD: 1.38%), the mean semen volume was 3.57 ml (SD: 1.76), and the mean count of them was 40.90×106 (SD: 33.72). Almost 54% were smokers [Table 1].

Correlation between sperm related parameters and dietary components

Table 2 presents Dietary intakes of energy, selected nutrients and minerals of study participants between different quartiles of intake. nutrients and minerals were evaluated due to the influence of covariates, for example there was a significant positive relationship between the energy intake, cholesterol, Potassium and quartiles (P<0.001).

Association between dietary fat intakes and sperm parameters

Tables 3 presents the multivariate adjusted model of dietary intake of fats and sperm quality parameters. The total motility was positively associated with Poly-unsaturated fatty acid intake (P-value=0.03), being higher for Q3 compared with first quartile of intake. The intake of Poly-unsaturated fatty acid for third quartile was 30.72 g per day. Differences were also found in the total motility and Omega-3 fatty acid intakes in the second, third and fourth quartile compared with the lowest quartile of intake (P-value <0.001, 0.022, <0.001). Furthermore, Omega-6 fatty acid intakes in the Q4 was positively associated with sperm motility (P-value=0.02). Moreover, there was significant association between Omega-3 fatty acid in second, third and fourth quartiles of intake and sperm normal morphology (P-value.: 0.003, 0.019 and 0.005) compared with first quartile.

Association between dietary mineral intakes and sperm parameters

Tables 4 presents the multivariate adjusted model of dietary intake of minerals and sperm quality parameters. The findings showed that there was a significant negative association between second quartile of sodium and calcium intake and sperm volume (P-value= 0.04) compared with first quartile. There was no significant difference between intake of other minerals intake and sperm parameters.

Table 1: Demographic characteristics of participants

Characteristics	Mean ± SD
Age (year)	33.66 ± 6.4
BMI (kg/m^2)	26.12 ± 5.33
Weight (kg)	79.24 ± 18.39
Waist Circumference (cm)	93.61 ± 20.13
Hip Circumference (cm)	96.89 ± 21.75
Volume (ml)	3.57 ± 1.76
Count (n × 10^6)	40.90 ± 33.72
Total Motility (%)	41.05 ± 16.58
Morphology (%)	2.59 ± 1.38
Energy Intake (Kcal)	3001.30 ± 659.11
Carbohydrate Intake (g)	619.77 ± 306.28
Protein Intake (g)	152.88 ± 66.91
Fat Intake (g)	154.54 ± 78.45
Physical Activity	
A. Inactive (%)	136 (34%)
B. Minimally activity (%)	157 (39.25%)
C. Highly activity (%)	107 (26.75%)
Smoking Status	
A. Current smokers (%)	219 (54.75%)
B. Never smokers (%)	160 (40%)
C. Ex-smokers (%)	21 (5.25%)

[1] All values are means ± standard error (SE) and Percent.

DISCUSSION

The present cross-sectional study sought to investigate the relationship between dietary fat and mineral intake with semen quantity and quality. Our finding indicates an association of Poly-unsaturated fatty acid, sodium and calcium intake with sperm normal morphology, total motility and sperm volume. Several studies have shown an association between dietary components and semen quality parameters as a proxy for male fertility [10,15,16]. However, the results are conflicting, in this context. Indeed, relatively small sample sizes in previous studies, as well as, the effect of ethnic differences, might considered the cause of contradictory findings, which highlights the necessity of further research to yield a reliable conclusion.

Fatty acid composition in spermatozoa has been shown to be important for the sperm function and semen quality [17]. The membrane-incorporated fatty acids are vital for sperm viability, sperm motility and the fusion process between the oocyte and

Table 2: Dietary intakes of energy and selected nutrients of study participants between different quartiles of minerals [1]

	Q1	Q2	Q3	Q4	P-value
Energy (Kcal)	2151.43±232.28	2723.23±162.61	3284.06±119.02	3846.48±214.71	<0.001
Carbohydrate (g)	345.85±54.47	454.51±27.32	616.28±74.73	1073.14±264.74	<0.001
Protein (g)	82.03±8.32	115.99±9.89	163.53±22.30	254.40±23.81	<0.001
Fat (g)	80.10±9.21	107.69±6.52	157.86±21.68	272.91±53.72	<0.001
Cholestrol (mg)	188.67±49.86	308.28±35.37	563.72±101.65	1184.54±343.28	<0.001
Saturated fatty acid (g)	19.58±2.90	32.55±4.80	50.60±4.57	84.11±24.53	<0.001
Mono-unsaturated fatty acid (g)	27.93±3.02	35.87±2.38	53.87±6.04	88.77±22.11	<0.001
Poly-unsaturated fatty acid (g)	17.58±2.73	24.40±2.53	30.72±1.88	62.33±27.70	<0.001
Omega-3 fatty acid (g)	0.37±0.16	0.81±0.09	1.31±0.18	2.95±2.20	<0.001
Omega-6 fatty acid (g)	0.12±0.04	0.28±0.04	0.57±0.11	0.70±0.91	<0.001
Sodium (mg)	3539.65±767.61	5195.36±379.34	6785.42±479.27	11153.15±3569.93	<0.001
Pottasium (mg)	3015.45±733.64	4629.93±403.12	6059.16±727.23	9265.92±2041.48	<0.001
Calcium (mg)	834.35±133.91	1237.98±140.64	1696.10±110.82	3057.32±768.05	<0.001
Magnesium (mg)	1.98±0.29	2.81±0.30	4.14±0.97	9.63±4.01	<0.001
Phosphorus (mg)	355.24±63.24	580.42±63.21	820.99±63.14	1227.48±137.21	<0.001
Iron (mg)	17.69±3.11	25.16±1.40	33.06±4.39	59.55±9.10	<0.001
Zinc (mg)	5.36±1.13	9.29±0.91	13.02±1.49	20.76±3.84	<0.001
Copper (mg)	116.30±18.03	170.35±19.69	265.61±38.26	455.43±67.24	<0.001

[1]All values are means ± standard error (SE). [2] Obtained from ANCOVA.

Table 3: Multivariable- adjusted odds ratio for abnormal semen quality across quartiles of Dietary fat intake [1]

			Volume (ml)			**Count (n × 10^6)**			**Total motility (%)**			Normal morphology (%)		
Fatty Acids			**OR**	**Beta (CI 95%)**	**P**	**OR**	**Beta (CI 95%)**	**P**	**OR**	**Beta (CI 95%)**	P	OR	Beta (CI 95%)	P
Cholestrol	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.95	-0.04 (-0.52, 0.44)	0.86	0.03	-3.40 (-12.68, 5.87)	0.47	1.77	0.57 (-3.98, 5.13)	0.8	1	0.004 (-0.37, 0.38)	0.98
		Q3	1.09	-0.09 (-0.38, 0.57)	0.7	0.0003	-7.89 (-17.12, 1.33)	0.09	0.02	-3.61 (-8.15, 0.91)	0.11	0.73	-0.30 (-0.68, 0.07)	0.11
		Q4	1.09	0.08 (-0.39, 0.57)	0.71	0.13	-2.003 (-11.25, 7.25)	0.67	0.17	-1.76 (-6.31, 2.78)	0.44	1.05	0.04 (0.33, 0.43)	0.79
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.91	-0.9 (-0.58, 0.40)	0.72	0.01	-3.96 (-13.51, 5.57)	0.41	2.28	0.82 (-3.88, 5.53)	0.73	1.01	0.01 (-0.38, 0.40)	0.95
		Q3	0.93	-0.06 (-0.57, 0.44)	0.8	0.0005	-7.50 (-17.31, 2.30)	0.13	0.025	-3.68 (-8.52, 1.16)	0.13	0.78	-0.23 (-0.64, 0.16)	0.24
		Q4	1.02	0.02 (-0.48, 0.52)	0.93	1.27	0.24 (-9.40, 9.88)	0.96	0.21	-1.51 (-6.27, 3.24)	0.53	1.06	0.06 (-0.33, 0.46)	0.75
Saturated fatty acid	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.9	-0.10 (-0.59, 0.39)	0.69	1.28	0.25 (-9.29, 9.79)	0.95	1.33	0.32 (-4.35, 5.01)	0.89	0.98	-0.01 (-0.41, 0.37)	0.93
		Q3	0.91	-0.08 (-0.56, 0.39)	0.72	0.05	-2.85 (-12.09, 6.39)	0.54	0.03	-3.32 (-7.86, 1.20)	0.15	0.96	-0.03 (-0.41, 0.34)	0.87
		Q4	1.11	-0.10 (-0.38, 0.60)	0.66	6.64	1.89 (-7.57, 11.36)	0.69	0.48	-0.72 (-5.37, 3.92)	0.76	1.02	0.02 (-0.36, 0.41)	0.89
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.74	-0.29 (-0.82, 0.23)	0.27	0.37	-0.95 (-11.14, 9.17)	0.84	1.9	0.64 (-4.36, 5.65)	0.8	1.1	0.09 (-0.32, 0.51)	0.65
		Q3	0.82	-0.19 (-0.69, 0.30)	0.44	0.03	-3.35 (-12.98, 6.27)	0.49	0.06	-2.76 (-7.51, 1.98)	0.25	0.97	-0.02 (-0.41, 0.37)	0.91
		Q4	0.9	-0.10 (-0.65, 0.45)	0.71	70.5	4.25 (-6.38, 14.90)	0.43	1.18	06.16 (-5.08, 5.41)	0.95	1.18	0.17 (-0.26, 0.61)	0.44
Mono-unsaturated fatty acid	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.82	-0.19 (-0.68, 0.30)	0.44	0.34	-1.05 (-10.54, 8.42)	0.82	8.18	2.10 (-2.55, 6.75)	0.37	1.27	0.24 (-0.14, 0.63)	0.21
		Q3	1.01	0.01 (-0.45, 0.49)	0.93	0.02	-3.77 (-12.84, 5.29)	0.41	0.09	-2.38 (-6.83, 2.06)	0.29	0.88	-0.12 (-0.49, 0.24)	0.51
		Q4	1.26	0.23 (-0.27, 0.74)	0.37	16.3	2.79 (-7.01, 12.60)	0.57	2.2	0.78 (-4.02, 5.60)	0.74	1.18	0.16 (0.23, 0.56)	0.41
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.67	-0.39 (-0.91, 0.12)	0.14	2.26	0.81 (-9.24, 10.88)	0.87	15.6	2.74 (-2.20, 7.70)	0.27	1.42	0.35 (-0.05, 0.76)	0.09
		Q3	0.79	-0.22 (-0.75, 0.29)	0.39	0.27	-1.27 (-11.38, 8.83)	0.8	0.14	-1.95 (-6.92, 3.02)	0.44	1.03	0.03 (-0.37, 0.45)	0.85
		Q4	0.95	-0.04 (-0.61, 0.53)	0.88	404.73	6.003 (-5.08, 17.09)	0.28	5.58	1.71 (-7.73, 7.17)	0.53	1.4	0.33 (-0.11, 0.79)	0.14
Poly-unsaturated fatty acid	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	1.04	0.04 (-0.44, 0.54)	0.84	0.22	7.73 (-1.70, 17.18)	0.1	0.08	-2.42 (-7.07, 2.23)	0.3	0.8	-0.21 (-0.60, 0.17)	0.27
		Q3	1.15	0.14 (-0.34, 0.62)	0.57	0.36	-1.01 (-10.21, 8.18)	0.82	0.008	-4.77 (-9.30, -0.23)	**0.03**	0.72	-0.31 (-0.69, 0.06)	0.1
		Q4	1.19	0.17 (-0.31, 0.67)	0.48	8410.08	9.03 (-0.40, 18.48)	**0.06**	0.62	-0.46 (-5.12, 4.19)	0.84	1.01	0.01 (-0.37, 0.40)	0.92
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.94	-0.05 (-0.56, 0.45)	0.84	1158.55	7.05 (-2.66, 16.77)	0.15	0.63	-2.75 (-7.54, 2.04)	0.26	0.85	-0.15 (-0.56, 0.24)	0.44
		Q3	0.88	-0.12 (-0.67, 0.42)	0.65	0.57	-0.54 (-11.01, 9.91)	0.91	0.003	-5.80 (-10.97, -0.64)	**0.02**	0.79	-0.22 (-0.65, 0.20)	0.3
		Q4	1	0.006 (-0.51, 0.52)	0.98	16147.4	9.68 (-0.23, 19.61)	**0.05**	0.61	-0.48 (-5.38, 4.41)	0.85	1.09	0.09 (0.01, 0.81)	0.65

Omega-3 fatty acid	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.79	-0.23 (-0.73, 0.26)	0.35	42.97	3.76 (-5.75, 13.27)	0.43	5323.14	8.57 (3.96, 13.19)	**<0.001**	1.78	0.58 (0.19, 0.97)	**0.003**
		Q3	0.91	-0.08 (-0.58, 0.41)	0.73	0.25	-1.35 (-10.89, 8.17)	0.78	224.82	5.41 (0.78, 10.04)	**0.022**	1.59	0.46 (0.07, 0.85)	**0.019**
		Q4	1.25	0.22 (-0.27, 0.72)	0.37	4.71	1.55 (-8.00, 11.11)	0.75	4940.16	8.50 (3.86, 13.14)	**<0.001**	1.74	0.56 (0.16, 0.94)	**0.005**
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.78	-0.24 (-0.74, 0.25)	0.33	82.06	4.40 (-5.13, 13.94)	0.36	6210.94	8.37 (4.09, 13.37)	**<0.001**	1.8	0.59 (0.20, 0.98)	**0.003**
		Q3	0.88	-0.12 (-0.62, 0.37)	0.62	0.13	-1.97 (-11.55, 7.61)	0.68	202.95	5.31 (0.64, 9.97)	**0.02**	1.6	0.47 (0.08, 0.86)	**0.018**
		Q4	1.24	-0.21 (-0.28, 0.71)	0.39	11.1	2.40 (-7.19, 12.01)	0.62	6520.45	8.63 (3.96, 13.30)	**<0.001**	1.75	0.56 (0.16, 0.95)	**0.005**
Omega-6 fatty acid	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.83	-0.17 (-0.67, 0.32)	0.48	5.08	1.62 (-7.91, 11.17)	0.73	1.8	0.59 (-4.09, 5.28)	0.8	1.11	0.10 (-0.28, 0.49)	0.59
		Q3	0.8	-0.21 (-0.71, 0.28)	0.4	0.46	-0.76 (-10.28, 8.75)	0.87	4.41	1.48 (-3.19, 6.16)	0.53	0.96	-0.03 (-0.43, 0.35)	0.84
		Q4	0.87	-0.13 (-0.63, 0.36)	0.59	6.63	1.89 (-7.67, 11.46)	0.69	264.36	5.57 (0.87, 10.27)	**0.02**	1.47	0.39 (-0.001, 0.78)	**0.05**
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.78	-0.24 (-0.74, 0.25)	0.33	3.68	1.30 (-8.34, 10.95)	0.79	2.44	0.89 (-3.85, 5.64)	0.71	1.13	0.12 (-0.27, 0.52)	0.53
		Q3	0.73	-0.30 (-0.80, 0.20)	0.24	0.48	-0.72 (-10.44, 8.99)	0.88	8.31	2.11 (-2.66, 6.89)	0.38	0.99	-0.005 (-0.40, 0.39)	0.97
		Q4	0.81	-0.19 (-0.70, 0.30)	0.44	9.001	2.19 (-7.54, 11.93)	0.65	492.63	6.19 (1.40, 10.98)	**0.01**	1.51	0.41 (0.01, 0.81)	**0.04**

[1]All values are odds ratios and 95% confidence intervals. Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

Table 4: Multivariable- adjusted odds ratio for abnormal semen quality across quartiles of Dietary minerals intake [1]

			Volume (ml)			Count (n × 10⁶)			Total motility (%)			Normal morphology (%)		
Minerals			**OR**	**Beta (CI 95%)**	**P**	**OR**	**Beta (CI 95%)**	**P**	**OR**	**Beta (CI 95%)**	**P**	OR	Beta (CI 95%)	P
Sodium	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.75	-0.28 (-0.76, 0.20)	0.25	0.01	-4.59 (-13.84, 4.65)	0.32	0.32	-1.11 (-5.66, 3.43)	0.63	1.07	0.07 (-0.30, 0.45)	0.7
		Q3	1.1	0.09 (-0.40, 0.59)	0.7	0.02	-3.89 (-13.42, 0.59)	0.42	0.02	-3.53 (-8.22, 1.15)	0.13	0.91	-0.09 (-0.48, 0.30)	0.65
		Q4	1.19	0.17 (-0.29, 0.64)	0.45	19.73	2.98 (-6.03, 12.002)	0.51	1.56	0.44 (-3.98, 4.88)	0.084	0.98	-0.01 (-0.38, 0.35)	0.92
	Adjusted	Q1	Ref.	Ref		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.58	-0.52 (-1.04, -0.006)	**0.04**	0.039	-3.22 (-13.26, 6.80)	0.52	0.45	-0.79 (-5.73, 4.14)	0.75	1.14	0.13 (-0.28, 0.54)	0.63
		Q3	0.85	-0.15 (-0.71, 0.40)	0.58	0.072	-2.62 (-13.39, 8.13)	0.63	0.04	-3.18 (-8.48, 2.10)	0.23	1.01	0.01 (-0.42, 0.45)	0.07
		Q4	0.89	-0.11 (-0.64, 0.42)	0.68	18.55	2.92 (-7.32, 13.16)	0.57	2.22	0.79 (-4.23, 5.83)	0.75	1.17	0.16 (-0.26, 0.58)	0.75
Pottasium	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.82	-0.19 (-0.67, 0.29)	0.43	0.004	-5.48 (-14.72, 3.74)	0.24	2.38	0.86 (-3.69, 5.42)	0.7	1.37	0.21 (-0.06, 0.70)	0.1
		Q3	1.25	0.22 (-0.28, 0.73)	0.38	0.003	-5.66 (-15.41, 4.08)	0.25	0.37	-0.98 (-5.80, 3.82)	0.68	1.12	0.11 (-0.28, 0.51)	0.57
		Q4	1.25	0.22 (-0.26, 0.70)	0.36	9.96	2.29 (-6.95, 11.55)	0.62	4.47	1.49 (-3.07, 6.06)	0.52	1.11	0.11 (-0.26, 0.49)	0.56
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.8	-0.21 (-0.72, 0.29)	0.4	0.01	-4.35 (-14.05, 5.33)	0.37	6.009	1.79 (-2.99, 6.57)	0.46	0.28	6.009 (0.05, 719.83)	0.15
		Q3	1.07	0.06 (-0.47, 0.61)	0.8	0.008	-4.80 (-15.19, 5.57)	0.36	1.16	0.15 (-4.97, 5.27)	0.95	0.14	1.16 (0.006, 195.91)	0.49
		Q4	1.05	0.05 (-0.45, 0.56)	0.82	36.89	3.60 (-6.20, 13.42)	0.47	13.04	2.56 (-2.27, 7.41)	0.29	0.21	13.04 (0.10, 1660.16)	0.28

Calcium	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.71	-0.32 (-0.81, 0.15)	0.18	0.0006	-7.27 (-16.51, 1.96)	0.12	0.11	-2.13 (-6.68, 2.41)	0.35	0.98	-0.013 (-0.39, 0.36)	0.94
		Q3	1.02	0.02 (-0.45, 0.51)	0.91	0.064	-2.73 (-11.97, 6.50)	0.56	0.57	-0.54 (-5.10, 4.004)	0.81	1.11	0.11 (-0.27, 0.49)	0.57
		Q4	0.98	-0.01 (-0.50, 0.46)	0.94	0.13	-2.03 (-11.30, 7.22)	0.66	0.11	-2.14 (-6.71, 2.41)	0.35	0.9	-0.10 (-0.48, 0.28)	0.6
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.59	-0.52 (-1.03, -0.011)	**0.04**	0.005	-5.18 (-15.03, 4.67)	0.3	0.18	-1.71 (-6.56, 3.14)	0.48	0.97	-0.02 (-0.42, 0.38)	0.92
		Q3	0.96	-0.03 (-0.53, 0.45)	0.88	0.06	-2.76 (-12.31, 6.78)	0.57	0.88	-0.12 (-4.82, 4.58)	0.96	1.14	0.13 (-0.25, 0.52)	0.5
		Q4	0.78	0.23 (-0.74, 0.27)	0.36	0.67	-0.38 (-10.26, 9.48)	0.93	0.26	-1.39 (-6.25, 3.47)	0.57	0.95	-0.04 (-0.45, 0.35)	0.81
Magnesium	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.85	-0.15 (-0.64, 0.32)	0.51	0.0004	-7.79 (-16.98, 1.38)	0.09	0.3	-1.18 (-5.72, 3.35)	0.6	1.1	0.10 (-0.28, 0.48)	0.6
		Q3	1.05	0.05 (-0.41, 0.52)	0.81	0.07	-2.59 (-11.59, 6.40)	0.57	0.12	-2.10 (-6.55, 2.34)	0.35	0.93	-0.06 (-0.44, 0.30)	0.71
		Q4	1.29	0.26 (-0.23, 0.76)	0.3	126.4	4.83 (-4.69, 14.37)	0.31	4.19	1.43 (-3.28, 6.15)	0.55	1.19	0.17 (-0.22, 0.56)	0.38
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.77	-0.24 (-0.76, 0.26)	0.34	0.0005	-9.77 (-19.62, 0.08)	**0.05**	0.67	-0.39 (-5.28, 4.49)	0.87	1.06	0.06 (-0.34, 0.47)	0.75
		Q3	0.85	-0.15 (-0.65, 0.35)	0.55	0.17	-1.72 (-11.31, 7.87)	0.72	0.18	-1.66 (-6.42, 3.10)	0.49	1.05	0.05 (-0.34, 0.45)	0.79
		Q4	1.03	0.03 (-0.50, 0.57)	0.89	371.56	5.91 (-4.36, 16.19)	0.25	14.83	2.69 (-2.40, 7.79)	0.29	1.33	0.28 (-0.13, 0.71)	0.18
Phosphorus	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.84	-0.16 (-0.66, 0.32)	0.5	0.01	-4.14 (-13.61, 5.32)	0.39	0.09	-2.32 (-6.98, 2.33)	0.32	0.95	-0.04 (-0.43, 0.34)	0.82
		Q3	0.86	-0.14 (-0.64, 0.34)	0.55	0.003	-5.70 (-15.21, 3.81)	0.24	0.02	-3.52 (-8.21, 1.15)	0.14	0.92	-0.08 (-0.47, 0.31)	0.68
		Q4	1.3	0.26 (-0.21, 0.75)	0.27	5.88	1.77 (-7.52, 11.06)	0.7	0.47	-0.73 (-5.31, 3.83)	0.75	0.96	-0.03 (-0.41, 0.35)	0.87
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.82	-0.19 (-0.70, 0.31)	0.45	0.04	-3.07 (-12.89, 6.74)	0.53	0.19	-1.63 (-6.46, 3.19)	0.91	0.68	-0.08 (-0.48, 0.31)	0.68
		Q3	0.65	-0.41 (-0.95, 0.12)	0.12	0.01	-4.26 (-14.67, 6.13)	0.42	0.02	-3.55 (-8.67, 1.57)	0.98	0.95	-0.01 (-0.44, 0.41)	0.95
		Q4	1.05	0.05 (-0.45, 0.56)	0.83	12.46	2.52 (-7.31, 12.36)	0.61	0.81	-0.20 (-5.04, 4.63)	1.06	0.74	0.06 (-0.33, 0.47)	0.74
Iron	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.91	-0.08 (-0.58, 0.41)	0.73	0.01	-4.36 (-13.85, 5.12)	0.36	0.04	-3.06 (-7.74, 1.61)	0.19	0.93	-0.06 (-0.45, 0.32)	0.75
		Q3	0.95	-0.04 (-0.53, 0.43)	0.84	0.009	-4.67 (-13.91, 4.57)	0.32	0.02	-3.69 (-8.24, 0.86)	0.11	0.97	-0.02 (-0.40, 0.36)	0.9
		Q4	1.34	0.29 (-0.17, 0.76)	0.21	176.6	5.17 (-3.83, 14.18)	0.26	0.71	-0.33 (-4.78, 4.10)	0.88	0.95	-0.04 (-0.41, 0.33)	0.83
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.87	-0.13 (-0.64, 0.38)	0.61	0.03	-3.46 (-13.37, 6.44)	0.49	0.05	-2.85 (-7.72, 2.02)	0.25	0.91	-0.09 (-0.50, 0.31)	0.66
		Q3	0.7	-0.34 (-0.89, 0.20)	0.21	0.17	-1.57 (-12.23, 8.73)	0.74	0.02	-3.69 (-8.85, 1.46)	0.16	1.08	0.08 (-0.35, 0.51)	0.71
		Q4	1.06	0.06 (-0.44, 0.56)	0.81	285.56	5.65 (-4.09, 15.39)	0.25	1.23	0.21 (-4.58, 5.00)	0.93	1.08	0.08 (-0.32, 0.48)	0.69
Zinc	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	1.1	0.09 (-0.40, 0.59)	69	0.01	-4.40 (-14.00, 5.19)	0.36	2.52	0.92 (-3.80, 5.65)	0.7	0.95	-0.04 (-0.44, 0.34)	0.81
		Q3	0.78	-0.23 (-0.71, 0.24)	0.32	0.01	-4.38 (-13.63, 4.85)	0.35	0.71	-0.33 (-4.88, 4.22)	0.88	1.02	0.02 (-0.33, 0.40)	0.88
		Q4	1.28	0.25 (-0.21, 0.72)	0.29	0.46	-0.76 (-9.82, 8.29)	0.86	1.14	0.13 (-4.32, 4.60)	0.95	0.87	-0.13 (-0.50, 0.23)	0.48
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.97	-0.02 (-0.55, 0.49)	0.91	0.004	-5.38 (-15.51, 4.74)	0.29	3.66	1.29 (-3.69, 6.29)	0.61	0.95	-0.04 (-0.46, 0.36)	0.82
		Q3	0.7	-0.35 (-0.88, 0.17)	0.19	1.14	0.13 (-10.04, 10.31)	0.97	1.17	0.16 (-4.85, 5.18)	0.94	1.03	0.03 (-0.38, 0.45)	0.87
		Q4	1.11	0.10 (-0.39, 0.60)	0.68	0.13	-1.99 (-11.64, 7.65)	0.68	1.96	0.67 (-4.08, 5.43)	0.78	0.91	-0.08 (-0.48, 0.31)	0.67

Copper	Crude	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.89	-0.11 (-0.60, 0.38)	0.65	0.0008	-7.01 (-16.48, 2.44)	0.14	0.06	-2.70 (-7.36, 1.95)	0.25	1.06	0.05 (-0.33, 0.45)	0.76
		Q3	1.06	0.06 (-0.42, 0.54)	0.79	0.34	-1.07 (-10.36, 8.21)	0.82	0.08	-2.41 (-6.99, 2.15)	0.29	1.03	0.03 (-0.35, 0.41)	0.87
		Q4	1.26	0.23 (-0.26, 0.72)	0.36	3.27	1.18 (-8.32, 10.70)	0.8	1.44	0.37 (-4.31, 5.05)	0.87	1.04	0.04 (-0.35, 0.43)	0.83
	Adjusted	Q1	Ref.	Ref.		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.	
		Q2	0.87	-0.13 (-0.64, 0.36)	0.58	0.001	-6.41 (-16.01, 3.18)	0.19	0.07	-2.58 (-7.32, 2.14)	0.28	1.02	0.02 (-0.37, 0.41)	0.91
		Q3	0.84	-0.13 (-0.69, 0.36)	0.53	5.3	1.66 (-8.44, 11.78)	0.74	0.21	-1.54 (-6.53, 3.44)	0.54	1.14	0.13 (-0.28, 0.54)	0.53
		Q4	1.05	0.05 (-0.46, 0.57)	0.84	7.9	2.06 (-7.85, 11.99)	0.68	2.5	0.92 (-3.97, 5.81)	0.71	1.13	0.12 (-0.28, 0.53)	0.53

[1]All values are odds ratios and 95% confidence intervals. Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

the spermatozoon [17]. In human semen, about thirty fatty acid molecular species were identified [18], ranging between SFAs, PUFAs, and MUFAs (n-3 and n-6 PUFAs), which have been shown to be specifically associated with semen quality(19). The results of recent studies have sometimes been in favor or against the results of the present study. Safarinejad et al.(20), found lower levels of n-3 PUFA (ALA, EPA, and DHA) and higher levels of n-6 PUFAs (LA and ARA) in blood plasma and in spermatozoa of infertile compared to fertile men. Other authors reported a lower seminal n-6/n-3 ratio in fertile men compared to the infertile ones(21). According to recent studies, dietary fish oil had significant positive effects on all sperm quality and quantity parameters [22]. Fish oil is a major source of docosahexaenoic acid (DHA, C22:6 n-3) and eicosapentaenoic acid (EPA, C20:5 n-3). It improves semen quality and quantity in vitamin E supplemented humans [23]. On the other hand, based on evidence, monounsaturated fatty acids (MUFAs) are negatively linked to sperm motility and sperm concentration [21,24].

We also found a negative association between calcium intake and sperm volume. The possible effect of calcium on male fertility is highly controversial. Hong Liang et al. [25], found a negative association between calcium concentration and calcium/magnesium ratio with sperm concentrations. In contrast to the present study, Eslamian, G et al. [7], have reported no significant relationship between calcium and sperm parameters. In addition, Prien SD et al(26). Found a statistically significant decrease in seminal Ca++ which was observed in men with decreased motility compared to men with normal sperm motility. Calcium ions have a paradoxical effect on sperm motility [27]. In ejaculated semen, calcium ions inhibit sperm motility, whereas, in the epididymis, calcium ions stimulate immature sperm. Maturation processes change the response of sperm to calcium ions. Calcium transport inhibitors and calcium binding substances are secreted by male accessory sexual organs and mixed with sperm during ejaculation [27].

According to recent studies, similar to our study, sodium intake showed a negative effect against semen quality. In human studies, "High-sodium diet" was correlated with an elevated prevalence of abnormal morphology sperm [7]. In addition to the amount of salt that is added to food on a daily basis in cooking, there is also some salt from natural meat and plant sources in food. It could therefore be inferred that daily high salt intake occurs frequently and individuals are often unaware of the amount of salt consumed. Food groups such as processed foods alone account for 80% of daily salt intake [28]. The recent estimation of human salt consumption is nearly 8 to 12 grams per day [29,30], and this amount is higher than the recommended daily intake of 1.5-2.0 g of salt. In animal studies, high-salt diet plays a negative role in sperm function, Including reduced testicular weight, disturbances in hormonal regulation, alterations in testicular morphology and gene expression related to semen quality in males [31].

The present study, like other cross-sectional studies, is not able to determine the cause-and-effect relationship between the variables and it is suggested that clinical trial or case-control studies be performed to confirm the results. Another limitation is that plasma or semen levels of minerals and fatty acids were not considered in this study. Finally, the 168-item food frequency questionnaire has some limitations in recording food intakes and relies on the individual's memory and is not accurate in the elderly or illiterate people so the use of three-day food recall can be useful in future studies.

CONCLUSION

In conclusion, this study with high sample size, provides important data into the association between dietary intake of Poly-unsaturated fatty acid and mineral intake and semen quality. Our investigation has found that dietary intake of Poly-unsaturated fatty acid is correlated with sperm normal morphology and total motility. Also we found an association between calcium and sodium intake and sperm volume in Iranian infertile men. However, more studies are needed to confirm these findings and provide the evidence needed to exert these findings into clinical practice.

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