Role of Dietary Antioxidants and Vitamins Intake in Semen Quality Parameters: A Cross-sectional Study

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Research

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Abstract

Objective

Infertility had an increasing trend between couples in Iran. Several factors such as lifestyle, physical activity, unhealthy dietary habits and stress are associated with production of ROS in seminal fluid. The aim of this study was to identify the role of dietary antioxidants and vitamins intake on semen quality parameters, among Iranian infertile men.

Methods

This cross-sectional study was performed on 400 newly diagnosed infertile men in Yazd Reproductive sciences Institute from July 2019 to December 2019. The presence of infertility was confirmed by an expert andrologist, based on WHO criteria. Dietary antioxidants and vitamins intake were assessed using a 168 items semi-quantitative food frequency questionnaire (FFQ).

Results

We found an association between semen volume and Alpha Carotene dietary intake, total motility and Beta Cryptoxanthin dietary intake, and sperm count with riboflavin intake ($P = 0.03$).

Conclusions

We concluded that dietary intake of Alpha Carotene, Beta Cryptoxanthin, and Riboflavin are related to sperm count, semen volume and total motility in Iranian infertile men, respectively. Our data suggest that that adhering to a diet that is rich in sources of antioxidant and vitamin can have a positive effect on men’s sexual health. However, more research is needed to confirm these relations and provide the evidence needed to exert these findings into clinical practice.

Introduction

Male infertility is one of the major stressful factors which affects almost 40–50% of all infertile couples (1). Prevalence of infertility has experienced an increasing trend between couples in Iran(2). Also reduce semen quality and impaired sperm function have been considered as the most common causes of infertility in men(3). Spermatozoa consist of 50 to 75 mitochondria, as other kind of cells that accomplish aerobic metabolism, is related to assembly free reactive oxygen species (ROS) such as superoxide anion ($•O_2^-$), hydroxyl radicals (•OH), hydrogen peroxide (H_2O_2) and nitric oxide (NO)(4). Reactive oxygen species (ROS) play a crucial role in sperm functions through activation of intracellular mechanisms, such as sperm capacitation associated-events(5). However, higher level of ROS in the reproductive tract lead to sperm DNA damage, lipid oxidation and depletes sperm antioxidant system(5). Imbalance between level of ROS and antioxidants capacity has been reported to reduced sperm quality(6). There are evidence that spermatozoa membrane is full of polyunsaturated fatty acids (PUFAs), that improve membrane flexibility(7) and increases the risk of their vulnerability to oxidants (8) .In the seminal plasma, several antioxidant mechanisms protect spermatozoa contrary to oxidative stress(9).

Furthermore, several factors in lifestyle such as stress and anxiety, smoking, alcohol consumption, pesticides in food, unhealthy dietary habits are associated with production of ROS in semen fluid(10–15). Unhealthy eating habits such as high intake of hydrogenated oils, processed meats, fried foods, synthetic dyes in food and low intake of rich sources of antioxidants, such as leafy green vegetables and fruits lead to Increase ROS level (16, 17). Regarding the association of ROS and antioxidants with men's Sexual Health, the dietary antioxidants and vitamins may play an important role in the progression of male infertility. Few studies have conducted on the relationship between dietary antioxidants and male infertility. Most studies focused on effect antioxidant supplementation on semen quality parameters, instead of assessing antioxidants status that intake from diets (18–22). Also, available evidence show that high dose antioxidant supplementation is associated with inconsistent results which called "antioxidant paradox" (23). specific negative effects have been reported for many of the usually recommended antioxidants such as selenium or vitamins C and E. Selenium intake and increased seminal levels of selenium were (≥ 80 ng/ml) were associated with declined motility(20, 24). Thus, due to the limited evidence on status of antioxidants dietary intake in infertile men, aim of this study was to evaluate the role of dietary antioxidants and vitamins intake in semen quality parameters and sperm functions in Iranian infertile men.

Materials And Methods

Study population

In this cross-sectional study, we recruited 400 infertile men from Yazd Reproduction Research Institute, diagnosed by andrologist's indices participated to our study from July 2019 to December 2019. Inclusion criteria include age between 20 to 55 years, being married, normal morphology less than 4%, semen volume less than 1.5 ml, progressive motility less than 40% and sperm count less than 20 million per milliliter. Also, exclusion criteria include testicular atrophy, hypospadias, chronic diseases, stenosis, varicocele, ejaculatory disorder, non-response to more than 35 items of food frequency questionnaire adherence to specific diets and underreporting and over-reporting of energy intake (more than 4,200 and less than 800)(25, 26). All subjects completed the consent at the baseline of the study. General and dietary information was collected by trained interviewer.

Physical examination and lifestyle variable

Physical activity data were accumulated using a validated and reliable questionnaire (International Physical Activity Questionnaire) (27). This form provides information about levels of strenuous activity, moderate activity, inactivity and walking. Furthermore, we assembled the data regarding duration (minutes per day) and frequency (days per week) for all types of activities. Socioeconomic status (SES) of the participants was determined according to variables, such as home situation (landlord-tenant), number of overseas trips, washing machine and dishwasher (yes-no), has car (yes-no), individual occupation, education (number of years of study).

Anthropometric data

Anthropometric data such as Waist to hip ratio (WHR) and Body mass index (BMI) calculated according to standard protocol of World Health Organization (WHO), based on no shoes and minimal clothing, by using Falcon scales (Seca, Hamburg, Germany) to the nearest 0.1 kg(28). 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 hips are the widest part of buttocks and. BMI and WHR were identified based on this formula: weight (kg)/height (m2) and WC (cm)/HC (cm), respectively(28).

Dietary assessment

Dietary intake was assessed by using a 168 items semiquantitative Food Frequency Questionnaire (FFQ). The validity of this questionnaire is confirmed in Iran (29). The FFQ 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 interviewer, by interviewing. The dietary antioxidants and vitamins intake were determined by computer program from the food- frequency data, using standard portion sizes and the vitamin contents given in the food composition tables. Household measurements were monitored by a nutritionist to calculate the total energy and nutrients consumed in actual food consumption (grams per day). The dietary habits of each person were assessed one year prior to infertility diagnosis. Information on alcohol use was not collected for cultural reasons and was therefore not analyzed.

Semen analysis

Semen samples should be assembled after three days of abstinence. Before conveying the samples into the container, the temperature of the container should be close to the body temperature of 37 ° C. Semen samples were kept in sterile containers for 30 minutes. They were then evaluated and analyzed according to the WHO Fifth Edition Laboratory Guidelines(30). Four parameters including 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 outcomes variables. Average antioxidants and vitamins intake were expose variables. Based on the amount of intake, antioxidants and vitamins were divided into four groups. Lowest quartile of each micronutrient intake was considered as the reference group. To investigate the association between each micronutrient with sperm parameters, Linear regression was used for crude and adjusted model. The adjusted model included age, BMI, physical activity, smoking status and energy intake. For the crude and adjusted model, beta and confident interval 95% (CI 95%) were calculated. Also, covariance test (ANCOVA) used to calculated micronutrient mean in each quartile. For statistical analyses, STATA 14 (Stata Corp, College Station, Texas, USA) was used. P-value less than 0.5 considered as significant.

Results:

Our study population were Iranian infertile men, with the mean age of 33.66 years [standard deviation (SD): 6.4] and a BMI of 26.12 (SD: 5.33). Almost 54% were smokers. The mean semen volume was 3.57 ml (SD: 1.76), 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%) and the mean count of them was 40.90×10^6 (SD:33.72) (Table 1).

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)	
Hip Circumference (cm)	
Volume (ml)	93.61 ± 20.13
Count (n × 10^6)	96.89 ± 21.75
Total Motility (%)	3.57 ± 1.76
Morphology (%)	40.90 ± 33.72
Energy Intake (Kcal)	41.05 ± 16.58
Carbohydrate Intake (g)	2.59 ± 1.38
Protein Intake (g)	3001.30 ± 659.11
Fat Intake (g)	619.77 ± 306.28
Physical Activity	152.88 ± 66.91
A. Inactive (%)	154.54 ± 78.45
B. Minimally activity (%)	136 (34%)
C. Highly activity (%)	157 (39.25%)
Smoking Status	107 (26.75%)
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.

Table 2 presents dietary intakes of energy and selected nutrients of study participants between different quartile. These were evaluated due to the influence of covariates, for example there was a significant positive relationship between the energy intake, Lycopene, Vitamin B6 and quartiles ($P < 0.001$).

Table 2

Dietary intakes of energy and selected nutrients of study participants between different quartiles[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
Beta Carotene (µg)	1143.51 ± 326.55	2133.76 ± 337.45	3962.52 ± 597.84	7152.53 ± 1686.29	< 0.001
Alpha Carotene (µg)	78.48 ± 30.02	164.26 ± 17.29	273.24 ± 52.82	789.26 ± 522.59	< 0.001
Beta Cryptoxanthine (µg)	34.94 ± 12.65	94.27 ± 17.36	179.81 ± 39.9	388.49 ± 313.28	< 0.001
Lutein (µg)	713.13 ± 187.88	1122.69 ± 65.43	1650.79 ± 273.57	4534.43 ± 1663.49	< 0.001
Lycopene (µg)	1015.95 ± 501.66	2559.47 ± 438.00	4386.38 ± 900.92	11615.93 ± 6009.06	< 0.001
Alpha Tocopherol (mg)	8.31 ± 1.33	12.39 ± 0.52	14.81 ± 1.35	28.00 ± 21.97	< 0.001
Vitamin E (mg)	14.10 ± 2.37	19.69 ± 1.48	23.55 ± 1.32	39.64 ± 26.83	< 0.001
Vitamin C (mg)	60.36 ± 16.20	116.31 ± 20.56	171.53 ± 17.29	300.29 ± 107.26	< 0.001
Selenium (mg)	0.006 ± 0.006	0.910 ± 0.056	0.31 ± 0.10	0.68 ± 0.16	< 0.001
Vitamin A (REA) (µg)	299.87 ± 94.58	560.93 ± 59.81	1066.58 ± 276.21	4890.54 ± 4374.67	< 0.001
Thiamin (mg)	1.95 ± 0.39	3.07 ± 0.23	3.80 ± 0.28	6.49 ± 1.36	< 0.001
Riboflavin (mg)	1.87 ± 0.22	2.77 ± 0.43	3.73 ± 0.23	7.48 ± 2.19	< 0.001
Niacin (mg)	24.06 ± 2.72	32.05 ± 2.68	43.02 ± 7.04	75.17 ± 10.76	< 0.001

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

[2] Obtained from ANCOVA.

	Q1	Q2	Q3	Q4	P-value
Pantothenic Acid (mg)	1323.57 ± 180.41	2120.45 ± 238.25	2905.27 ± 297.43	4477.86 ± 463.83	< 0.001
Vitamin B6 (mg)	1.66 ± 0.22	2.46 ± 0.13	3.35 ± 0.46	5.02 ± 0.65	< 0.001
Folate (µg)	584.67 ± 46.15	775.06 ± 103.73	1142.163.27	2055.42 ± 539.21	< 0.001
Dietary Folate Equivalent (µg)	2.64 ± 0.78	6.72 ± 1.28	10.23 ± 1.20	50.09 ± 44.24	< 0.001
Vitamin B12 (µg)	22.63 ± 6.93	42.69 ± 3.72	62.82 ± 7.04	101.04 ± 28.29	< 0.001
[1] All values are means ± standard error (SE).					
[2] Obtained from ANCOVA.					

Tables 3 and 4 present the multivariate adjusted model of dietary intake of antioxidant, vitamins and semen parameters. The semen volume was associated with Alpha Carotene intake (P = 0.03), being higher for Q3 and Q4 than for Q2 of intake. The median intake of Alpha Carotene for the first quartile was 78 µg per day. Differences were also found in the total motility and Beta Cryptoxanthin intakes in the Q4 compared with the lowest quartile of intake (Ptrend¼0.03). However, the P for trends was not statistically significant for Beta Cryptoxanthin intakes and normal morphology (Ptrend¼0.05). Riboflavin intakes in the Q2 was associated with sperm count (Ptrend¼0.03). Other dietary intake of antioxidants and vitamins did not show statistically significant differences with the semen parameters.

Table 3

Multivariable- adjusted for abnormal semen quality across quartiles of Antioxidants intake[1].

			Volume (ml)		Count (n × 10^6)		Total motility (%)		Normal morphology (%)	
Antioxidants			Beta (CI 95%)	P	Beta (CI 95%)	P	Beta (CI 95%)	P	Beta (CI 95%)	P
Beta Carotene	Crude	Q1	Ref.	0.448	Ref.	0.28	Ref.	0.96	Ref.	0.89
	Adjusted	Q2	-0.19 (-0.69, 0.30)	0.211	-5.17 (-14.74, 4.39)	0.17	-0.11 (-4.83, 4.60)	0.40	0.17 (-0.21, 0.57)	0.31
		Q3		0.744		0.83		0.93		0.20
		Q4	-0.30 (-0.78, 0.17)	0.80	-6.39 (-15.62, 2.82)	0.33	-1.94 (-6.49, 2.61)	0.84	0.06 (-0.32, 0.44)	0.83
		Q1		0.24		0.16		0.50		0.86
		Q2	0.07 (-0.39, 0.54)	0.81	0.95 (-8.02, 9.92)	0.66	0.17 (-4.25, 4.60)	0.79	0.03 (-0.33, 0.40)	0.77
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			-0.06 (-0.60, 0.47)		-5.09 (-15.47, 5.29)		0.52 (-4.61, 5.67)		0.04 (-0.38, 0.47)	
			-0.28 (-0.77, 0.20)		-6.57 (-15.91, 2.75)		-1.58 (-6.21, 3.04)		0.03 (-0.35, 0.42)	
			0.05 (-0.41, 0.52)		1.99 (-7.09, 11.09)		0.58 (-3.92, 5.09)		0.05 (-0.32, 0.43)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count ($n \times 10^6$)		Total motility (%)		Normal morphology (%)	
Alpha Carotene	Crude	Q1	Ref.	**0.03**	Ref.	0.58	Ref.	0.72	Ref.	0.54
	Adjusted	Q2	-0.52 (-1.02, -0.02)	0.07	-2.68 (-12.25, 6.88)	0.33	-0.83 (-5.54, 3.87)	0.57	0.12 (-0.27, 0.51)	0.88
		Q3		0.23		0.83		0.62		0.57
		Q4	-0.44 (-0.92, 0.03)	0.11	-4.53 (-13.79, 4.71)	0.62	1.28 (-3.26, 5.83)	0.76	-0.02 (-0.40, 0.35)	0.82
		Q1		0.08		0.51		0.48		0.68
		Q2	-0.29 (-0.79, 0.19)	0.35	-1 (-10.49, 8.49)	099	-3.49 (-3.49, 5.84)	0.53	0.11 (-0.27, 0.50)	0.70
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			-0.42 (-0.94, 0.09)		-2.47 (-12.5, 7.55)		-0.76 (-5.71, 4.17)		0.04 (-0.36, 0.46)	
			-0.42 (-0.91, 0.06)		-3.15 (-12.6, 6.29)		1.65 (-3.0, 6.31)		-0.07 (-0.46, 0.31)	
			-0.24 (-0.74, 0.26)		-0.02 (-9.75, 9.71)		1.51 (-3.28, 6.31)		0.07 (-0.32, 0.47)	
Beta Cryptoxanthine	Crude	Q1	Ref.	0.54	Ref.	0.53	Ref.	0.55	Ref.	0.81
	Adjusted	Q2	0.15 (-0.33, 0.63)	0.55	2.89 (-6.35, 12.13)	0.74	1.37 (-3.15, 5.90)	0.89	0.04 (-0.33, 0.42)	0.51
		Q3		0.67		0.63		0.08		**0.05**
		Q4	-0.14 (-0.64, 0.34)	0.16	1.56 (-7.95, 11.07)	0.29	0.30 (-4.36, 4.96)	0.34	0.12 (-0.26, 0.51)	0.80
		Q1		0.62		0.72		0.77		0.65
		Q2	-0.10 (-0.60, 0.38)	0.99	-2.29 (-11.79, 7.19)	0.86	4.13 (-0.51, 8.79)	**0.03**	0.38 (-0.008, 0.76)	0.10
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			0.36 9-0.15, 0.87)		5.20 (-4.63, 15.05)		2.30 (-2.53, 7.14)		-0.05 (-0.45, 0.35)	
			-0.12 (-0.62, 0.37)		1.71 (-7.92, 11.36)		069 (-4.04, 5.43)		0.08 (-0.30, 0.48)	
			-0.0003 (-0.51, 0.51)		0.86 (-9.12, 10.86)		5.19 (0.28, 10.10)		0.33 (-0.07, 0.74)	

[1] All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count (n × 10^6)		Total motility (%)		Normal morphology (%)	
Lutein	Crude	Q1	Ref.	0.36	Ref.	0.64	Ref.	0.96	Ref.	0.65
	Adjusted	Q2	0.22 (-0.26, 0.71)	0.52	-2.17 (-11.49, 7.13)	0.26	-0.09 (-4.67, 4.48)	0.57	-0.08 (-0.47, 0.29)	0.64
		Q3		0.93		0.28		0.22		0.69
		Q4	0.15 (-0.32, 0.63)	0.49	-5.21 (-14.48, 4.04)	0.68	-1.31 (-5.87, 3.23)	0.99	-0.08 (-0.47, 0.29)	0.62
		Q1		0.88		0.51		0.68		0.79
		Q2	0.02 (-0.46, 0.50)	0.94	-5.06 (-14.33, 4.19)	0.53	-2.79 (-7.35, 1.75)	0.27	0.01 (-0.36, 0.39)	0.95
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			0.17 (-0.32, 0.66)		-1.96 (-11.45, 7.51)		0.02 (-4.64, 4.70)		-0.09 (-0.48, 0.29)	
			0.03 (-0.48, 0.55)		-3.34 (-13.32, 6.63)		-1.01 (-5.93, 3.90)		-0.0 (-0.46, 0.35)	
			0.01 (-0.48, 0.52)		-3.03 (-12.74, 6.67)		-2.64 (-7.42, 2.14)		-0.01 (-0.41, 0.38)	
Lycopene	Crude	Q1	Ref.	0.31	Ref.	0.93	Ref.	0.26	Ref.	0.11
	Adjusted	Q2	-0.25 (-0.75, 0.24)	0.36	0.40 (-9.12, 9.92)	0.12	2.63 (-2.05, 7.32)	0.86	0.31 (-0.07, 0.70)	0.18
		Q3		0.71		0.35		0.21		0.73
		Q4	-0.23 (-0.73, 0.26)	0.62	-7.41 (-17.005, 2.17)	0.97	-0.39 (-5.11, 4.32)	0.31	-0.26 (-0.65, 0.12)	0.18
		Q1		0.51		0.22		0.77		0.15
		Q2	0.08 (-0.37, 0.54)	0.58	-4.17 (-1.96, 4.60)	0.42	2.72 (-1.59, 7.05)	0.21	0.062 (-0.29, 0.42)	0.83
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			-0.12 (-0.63, 0.38)		-0.16 (-9.99, 9.65)		2.48 (-2.35, 7.32)		0.27 (-0.13, 0.67)	
			-0.16 (-0.68, 0.34)		-6.05 (-15.92, 3.81)		-0.71 (-5.57, 4.14)		-0.29 (-0.70, 0.10)	
			0.12 (-0.33, 0.59)		-3.62 (-12.50, 5.26)		2.75 (-1.62, 7.13)		0.03 (-0.32, 0.40)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count ($n \times 10^6$)		Total motility (%)		Normal morphology (%)	
Alpha Tocopherol	Crude	Q1	Ref.	0.90	Ref.	0.46	Ref.	0.28	Ref.	0.44
		Q2	-0.03 (-0.53, 0.47)	0.69	-3.54 (-13.12, 6.04)	0.24	-2.55 (-7.27, 2.16)	0.64	-0.15 (-0.54, 0.24)	0.63
		Q3	-0.09 (-0.56, 0.37)	0.77	-5.41 (-14.47, 3.64)	0.85	-1.03 (-5.49, 3.42)	0.93	-0.08 (-0.46, 0.28)	0.22
		Q4	-0.06 (-0.55, 0.41)	0.64	-0.86 (-10.15, 8.41)	0.78	-0.18 (-4.75, 4.37)	0.41	0.23 (-0.14, 0.61)	0.58
	Adjusted	Q1	Ref.	0.64	Ref.	0.64	Ref.	0.74	Ref.	0.75
		Q2	-0.12 (-0.63, 0.39)	0.56	-1.36 (-11.29, 8.55)	0.64	-2.04 (-6.94, 2.85)	0.94	-0.11 (-0.52, 0.29)	0.16
		Q3	-0.11 (-0.61, 0.38)		-2.23 (-11.84, 7.37)		-0.79 (-5.53, 3.94)		-0.06 (-0.45, 0.33)	
		Q4	-0.15 (-0.66, 0.36)		2.29 (-7.56, 12.15)		0.17 (-4.68, 5.04)		0.28 (-0.11, 0.69)	
Vitamin E	Crude	Q1	Ref.	0.98	Ref.	0.91	Ref.	0.83	Ref.	0.77
		Q2	-0.005 (-0.49, 0.48)	0.89	0.51 (-8.78, 9.82)	0.72	0.48 (-4.08, 5.06)	0.49	-0.05 (-0.43, 0.32)	0.36
		Q3	0.03 (-0.46, 0.53)	0.95	-1.68 (-11.21, 7.84)	0.75	-1.61 (-6.30, 3.06)	0.75	-0.17 (-0.57, 0.21)	0.68
		Q4	-0.01 (-0.51, 0.48)	0.87	-1.53 (-11.08, 8.01)	0.80	-0.73 (-5.42, 3.96)	0.75	0.08 (-0.30, 0.47)	0.91
	Adjusted	Q1	Ref.	0.91	Ref.	0.97	Ref.	0.53	Ref.	0.40
		Q2	-0.03 (-0.52, 0.45)	0.65	1.20 (-8.20, 10.62)	0.85	0.75 (-3.89, 5.39)	0.80	0.02 (-0.40, 0.36)	0.39
		Q3	0.02 (-0.48, 0.54)		-0.13 (-10.08, 9.80)		-1.55 (-6.46, 3.34)		-0.17 (-0.58, 0.23)	
		Q4	-0.11 (-0.64, 0.40)		0.93 (-9.14, 11.02)		-0.61 (-5.58, 4.35)		0.18 (-0.23, 0.59)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count (n × 10^6)		Total motility (%)		Normal morphology (%)	
Vitamin C	Crude	Q1	Ref.	0.23	Ref.	0.28	Ref.	0.89	Ref.	0.87
	Adjusted	Q2	-0.29 (-0.77, 0.18)	0.10	-5.10 (-14.36, 4.46)	0.23	0.31 (-4.25, 4.87)	0.55	0.33 (-0.04, 0.71)	0.34
		Q3		0.63		0.85		0.34		0.57
		Q4	-0.41 (-0.91, 0.08)	0.28	-5.74 (-15.31, 3.83)	0.36	1.43 (-3.28, 6.14)	0.74	0.18 (-0.20, 0.58)	0.17
		Q1		0.10		0.25		0.48		0.39
		Q2	-0.11 (-0.58, 0.35)	0.40	-0.82 (-9.83, 8.18)	0.95	2.13 (-2.29, 6.57)	0.27	0.10 (-0.26, 0.47)	0.46
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			-0.27 (-0.77, 0.22)		-4.40 (-14.04, 5.22)		0.92 (-3.83, 5.68)		0.27 (-0.12, 0.67)	
			-0.42 (-0.93, 0.09)		-5.74 (-15.57, 4.07)		1.74 (-3.11, 6.59)		0.17 (-0.22, 0.58)	
			-0.20 (-0.67, 0.27)		0.14 (-8.99, 9.29)		2.50 (-2.01, 7.02)		0.14 (-0.23, 0.51)	
Selenium	Crude	Q1	Ref.	0.60	Ref	0.89	Ref.	0.68	Ref.	0.76
	Adjusted	Q2	-0.13 (-0.63, 0.36)	0.34	0.66 (-8.91, 10.24)	0.22	0.98 (-3.73, 5.70)	0.85	0.06 (-0.33, 0.45)	0.64
		Q3		0.90		0.62		0.66		0.62
		Q4	0.22 (-0.24, 0.70)	0.79	-5.63 (-14.66, 3.39)	0.53	-0.42 (-4.87, 4.02)	0.53	-0.06 (-0.43, 0.30)	0.89
		Q1		0.75		0.66		0.88		0.90
		Q2	0.02 (-0.45, 0.51)	0.94	-2.30 (-11.60, 7.00)	0.71	-1.00 (-5.58, 3.58)	0.74	-0.09 (-0.47, 0.29)	0.70
		Q3								
		Q4	Ref.		Ref.		Ref.		Ref.	
			-0.07 (-0.64, 0.49)		3.47 (-7.46, 14.41)		1.71 (-3.69, 7.11)		-0.02 (-0.48, 0.42)	
			0.09 (-0.47, 0.65)		-2.40 (-13.28, 8.47)		0.39 (-4.917, 5.76)		-0.02 (-0.47, 0.42)	
			-0.01 (-0.52, 0.48)		-1.80 (-11.50, 7.89)		-0.80 (-5.59, 3.98)		-0.07 (-0.47, 0.32)	

[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 for abnormal semen quality across quartiles of Dietary vitamins intake[1].

			Volume (ml)		Count ($n \times 10^6$)		Total motility (%)		Normal morphology (%)	
Vitamins			Beta (CI 95%)	P	Beta (CI 95%)	P	Beta (CI 95%)	P	Beta (CI 95%)	P
Vitamin A	Crude	Q1	Ref.	0.81	Ref.	0.86	Ref.	0.59	Ref.	1.00
	Adjusted	Q2	0.06 (-0.43, 0.55)	0.61	0.81 (-8.70, 10.34)	0.28	-1.25 (-5.95, 3.44)	0.78	5.83 (-0.39, 0.39)	0.20
		Q3	0.12 (-0.36, 0.63)	0.31	-5.22 (-14.78, 4.32)	0.77	-0.64 (-5.36, 4.06)	0.78	0.25 (-0.13, 0.64)	0.80
		Q4	0.25 (-0.23, 0.73)	0.87	1.36 (-7.87, 10.60)	0.81	-0.64 (-5.20, 3.91)	0.75	0.04 (-0.33, 0.42)	0.76
		Q1	Ref.	0.60	Ref.	0.25	Ref.	0.88	Ref.	0.31
		Q2	0.04 (-0.49, 0.58)	0.50	-1.26 (-11.61, 9.08)	0.67	-0.80 (-5.92, 4.32)	0.97	-0.06 (-0.49, 0.36)	0.72
		Q3	0.13 (-0.37, 0.65)		-5.73 (-15.65, 4.19)		-0.35 (-5.26, 4.56)		0.21 (-0.19, 0.62)	
		Q4	0.16 (-0.32, 0.66)		2.04 (-7.50, 11.58)		-0.07 (-4.80, 4.64)		0.07 (-0.32, 0.46)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count ($n \times 10^6$)		Total motility (%)		Normal morphology (%)	
Thiamin	Crude Adjusted	Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4	Ref. -0.19 (-0.69, 0.30) -0.06 (-0.54, 0.41) 0.25 (-0.21, 0.72) Ref. -0.39 (-0.92, 0.13) -0.27 (-0.79, 0.25) 0.01 (-0.49, 0.52)	0.45 0.79 0.28 0.14 0.31 0.94	Ref. -6.29 (-15.81, 3.23) -0.73 (-9.92, 8.45) 5.94 (-3.04, 14.92) Ref. -3.88 (-14.06, 6.28) 0.84 (-9.30, 11.00) 6.36 (-3.40, 16.14)	0.19 0.87 0.19 0.45 0.86 0.20	Ref. -2.08 (-6.78, 6.62) -3.49 (-8.03, 1.04) 0.02 (-4.41, 4.46) Ref. -1.80 (-6.83, 3.22) -3.30 (-8.33, 1.71) 0.33 (-4.50, 5.16)	0.38 0.13 0.99 0.48 0.19 0.89	Ref. -0.05 (-0.44, 0.34) -0.07 (-0.45, 0.30) -0.05 (-0.42, 0.31) Ref. 0.01 (-0.41, 0.43) -0.02 (-0.44, 0.39) 0.04 (-0.36, 0.44)	0.79 0.71 0.77 0.96 0.90 0.83
Riboflavin	Crude Adjusted	Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4	Ref. -0.15 (-0.63, 0.33) -0.19 (-0.69, 0.30) 0.12 (-0.34, 0.59) Ref. -0.40 (-0.92, 0.12) -0.13 (-0.65, 0.38) -0.17 (-0.70, 0.34)	0.53 0.44 0.60 0.13 0.60 0.50	Ref. -9.84 (-19.02, -0.67) -1.93 (-11.44, 7.57) 2.31 (-6.65, 11.29) Ref. -8.24 (-18.25, -1.77) -0.95 (-10.92, 9.00) 3.84 (-6.24, 13.93)	**0.03** 0.68 0.61 0.10 0.85 0.45	Ref. -1.56 (-6.12, 2.98) -2.05 (-6.76, 2.66) -0.17 (-4.62, 4.27) Ref. -0.75 (-5.73, 4.22) -1.58 (-6.53, 3.36) 0.78 (-4.23, 5.80)	0.49 0.39 0.93 0.76 0.53 0.75	Ref. -0.09 (-0.47, 0.28) 0.29 (-0.09, 0.69) -0.008 (-0.37, 0.36) Ref. -0.03 (-0.45, 0.38) 0.25 (-0.16, 0.66) 0.05 (-0.36, 0.47)	0.63 0.13 0.96 0.86 0.23 0.79

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count ($n \times 10^6$)		Total motility (%)		Normal morphology (%)	
Niacin	Crude	Q1	Ref.	0.42	Ref.	0.20	Ref.	0.23	Ref.	0.74
	Adjusted	Q2	-0.19 (-0.67, 0.28)	0.96	-5.96 (-15.15, 3.22)	0.41	-2.75 (-7.29, 1.78)	0.32	-0.06 (-0.44, 0.31)	0.73
		Q3	-0.01 (-0.52, 0.49)	0.27	-4.02 (-13.74,3.70)	0.29	-2.39 (-7.20, 2.40)	0.88	-0.07 (-0.47, 0.33)	0.99
		Q4	0.27 (-0.21, 0.75)	0.15	4.90 (-4.34, 14.15)	0.31	0.34 (-4.23, 4.91)	0.31	0.0001 (-0.38, 0.38)	0.96
		Q1	Ref.	0.20	Ref.	0.61	Ref.	0.51	Ref.	0.68
		Q2	-0.37 (-0.89, 0.13)	0.94	-5.09 (-15.06, 4.86)	0.30	-2.51 (-7.44, 2.42)	0.77	0.01 (-0.40, 0.42)	0.74
		Q3	-0.37 (-0.95, 0.20)		-2.87 (-14.00, 8.26)		-1.85 (-7.37, 3.66)		0.08 (-0.38, 0.54)	
		Q4	0.01 (-0.55, 0.51)		5.36 (-4.92, 15.64)		0.74 (-4.34, 5.84)		0.13 (-0.29, 0.55)	
Pantothenic Acid	Crude	Q1	Ref.	0.29	Ref.	0.19	Ref.	0.79	Ref.	0.25
	Adjusted	Q2	-0.26 (-0.75, 0.22)	0.44	-6.29 (-15.76, 3.18)	0.81	-0.62 (-5.29, 4.05)	0.54	0.22 (-0.16, 0.61)	0.52
		Q3	-0.18 (-0.66, 0.29)	0.26	-1.11 (-10.36, 8.13)	0.71	-1.42 (-5.98, 3.13)	0.99	0.12 (-0.25, 0.50)	0.64
		Q4	0.27 (-0.21, 0.77)	0.21	1.77 (-7.74, 11.29)	0.29	-0.008 (-4.70, 4.68)	0.98	0.09 (-0.29, 0.48)	0.35
		Q1	Ref.	0.14	Ref.	0.94	Ref.	0.72	Ref.	0.34
		Q2	-0.32 (-0.83, 0.18)	0.67	-5.22 (-15.04, 4.59)	0.47	-0.04 (-4.90, 4.82)	0.81	0.19 (-0.21, 0.59)	0.41
		Q3	-0.37 (-0.88, 0.13)		0.34 (-9.36, 10.11)		-0.85 (-5.69, 3.98)		0.19 (-0.20, 0.59)	
		Q4	0.11 (-0.40, 0.62)		3.64 (-6.35, 13.63)		0.58 (-4.36, 5.53)		0.17 (-0.24, 0.58)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count (n × 10^6)		Total motility (%)		Normal morphology (%)	
Vitamin B6	Crude	Q1	Ref.	0.22	Ref.	0.20	Ref.	0.54	Ref.	0.55
		Q2	-0.30 (-0.80, 0.19)	0.66	-6.11 (-15.62, 3.40)	0.59	-1.42 (-6.11, 3.25)	0.33	0.11 (-0.27, 0.50)	0.64
		Q3	0.10 (-0.36, 0.57)	0.25	-2.47 (-11.51, 6.56)	0.52	-2.17 (-6.63, 2.27)	0.73	-0.08 (-0.46, 0.28)	0.62
		Q4	0.28 (-0.20, 0.76)	0.06	3.01 (-6.24, 12.28)	0.39	0.78 (-3.78, 5.35)	0.71	0.09 (-0.28, 0.47)	0.40
	Adjusted	Q1	Ref.	0.76	Ref.	0.82	Ref.	0.59	Ref.	0.92
		Q2	-0.48 (-1.00, 0.03)	0.79	-4.36 (-14.39, 5.66)	0.45	-0.92 (-5.88, 4.03)	0.56	0.17 (-0.23, 0.59)	0.32
		Q3	-0.07 (-0.58, 0.43)		-1.12 (-10.89, 8.65)		-1.31 (-6.14, 3.51)		-0.01 (-0.42, 0.38)	
		Q4	0.07 (-0.45, 0.59)		3.83 (-6.21, 13.89)		1.45 (-3.51, 6.42)		0.20 (-0.20, 0.62)	
Folate	Crude	Q1	Ref.	0.89	Ref.	0.65	Ref.	0.81	Ref.	0.61
		Q2	-0.03 (-0.52, 0.46)	0.88	-2.14 (-11.60, 7.32)	0.95	-0.55 (-5.23, 4.12)	0.44	0.10 (-0.29, 0.49)	0.75
		Q3	0.03 (-0.44, 0.51)	0.32	-0.08 (-9.25, 9.08)	0.07	-1.77 (-6.31, 2.75)	0.74	-0.06 (-0.43, 0.31)	0.56
		Q4	0.24 (-0.24, 0.74)	0.63	8.74 (-0.71, 18.20)	0.66	0.77 (-3.90, 5.45)	0.84	0.11 (-0.28, 0.50)	0.39
	Adjusted	Q1	Ref.	0.77	Ref.	0.91	Ref.	0.46	Ref.	0.90
		Q2	-0.12 (-0.63, 0.39)	0.75	-2.15 (-12.00, 7.69)	0.15	-0.48 (-5.36, 4.38)	0.57	0.17 (-0.23, 0.58)	0.34
		Q3	-0.07 (-0.60, 0.44)		0.54 (-9.50, 10.59)		-1.84 (-6.82, 3.12)		0.02 (-0.39, 0.44)	
		Q4	0.08 (-0.46, 0.64)		7.62 (-2.98, 18.23)		1.49 (-3.76, 6.74)		0.21 (-0.22, 0.65)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

			Volume (ml)		Count (n × 10^6)		Total motility (%)		Normal morphology (%)	
Dietary Folate Equivalent	Crude	Q1	Ref.	0.53	Ref.	0.53	Ref.	0.29	Ref.	0.85
		Q2	0.15 (-0.34, 0.65)	0.34	-3.04 (-12.62, 6.53)	0.90	-2.49 (-7.19, 2.20)	0.61	0.03 (-0.35, 0.43)	0.16
		Q3	0.23 (-0.25, 0.71)	0.33	-0.54 (-9.87, 8.78)	0.58	1.17 (-3.40, 5.75)	0.48	0.26 (-0.11, 0.65)	0.61
		Q4	0.23 (-0.24, 0.70)	0.59	-2.50 (-11.53, 6.52)	0.46	-1.56 (-5.99, 2.86)	0.45	0.09 (-0.27, 0.46)	0.88
	Adjusted	Q1	Ref.	0.31	Ref.	0.70	Ref.	0.50	Ref.	0.20
		Q2	0.14 (-0.38, 0.66)	0.53	-3.74 (-13.82, 6.33)	0.94	-1.87 (-6.84, 3.09)	0.67	-0.03 (-0.44, 0.38)	0.59
		Q3	0.25 (-0.24, 0.75)		-1.87 (-11.44, 7.69)		1.61 (-3.09, 6.33)		0.25 (-0.14, 0.64)	
		Q4	0.15 (-0.34, 0.65)		0.34 (-9.19, 9.88)		-1.01 (-5.71, 3.68)		0.10 (-0.28, 0.49)	
Vitamin B12	Crude	Q1	Ref.	0.57	Ref.	0.19	Ref.	0.60	Ref.	0.81
		Q2	-0.14 (-0.64, 0.35)	0.96	-6.27 (-15.82, 3.28)	0.57	1.24 (-3.46, 5.95)	0.66	-0.04 (-0.44, 0.34)	0.38
		Q3	0.01 (-0.47, 0.49)	0.40	-2.66 (-11.93, 6.61)	0.75	-1.00 (-5.57, 3.57)	0.93	-0.16 (-0.54, 0.21)	0.55
		Q4	0.19 (-0.27, 0.67)	0.42	1.45 (-7.57, 10.47)	0.20	0.19 (-4.25, 4.64)	0.46	0.11 (-0.26, 0.48)	0.77
	Adjusted	Q1	Ref.	0.75	Ref.	0.95	Ref.	0.83	Ref.	0.52
		Q2	-0.20 (-0.71, 0.30)	0.88	-6.31 (-16.05, 3.42)	0.71	1.78 (-3.03, 6.61)	0.73	-0.05 (-0.46, 0.34)	0.34
		Q3	-0.08 (-0.58, 0.42)		-0.25 (-9.93, 9.42)		-0.51 (-5.30, 4.27)		-0.13 (-0.52, 0.26)	
		Q4	0.03 (-0.45, 0.53)		1.77 (-7.69, 11.23)		0.82 (-3.86, 5.50)		0.18 (-0.20, 0.57)	

[1]All values are odds ratios and 95% confidence intervals.

Adjusted model: Adjusted for age, BMI, physical activity, smoking status and energy intake.

Discussion:

We found an association between the dietary intake of several antioxidants, and vitamins, including Alpha Carotene, Beta Cryptoxanthin and Riboflavin, and the semen volume, sperm count and total motility in Iranian infertile men. For carotenoids, Eskenazi et al. founds a positive association between b-carotene and perm concentrations and progressive sperm motility (31). In aforementioned study cryptoxanthin and lycopene were not analyzed. Mendiola et al. reported that lycopene but not alpha Carotene and beta-carotene was associated with good semen quality(32). There is evidence that carrot, red palm oil, some cultivars of squash, pumpkin, burrito has high amounts of alpha-carotene (33).

we also found an association between Beta Cryptoxanthin and total sperm motility. Lorenzo Y et al. suggested that Beta cryptoxanthin plays a role in the protection of spermatozoa against oxidative stress(34). One possible mechanism would be the conversion of cryptoxanthin to vitamin A(35). These molecules play crucial roles as chromophores and signaling molecules(36). Suggested mechanism is that Beta-cryptoxanthin is as an affective antioxidant which protects cells against ROS (37, 38). Beta-Cryptoxanthin Seems to have higher absorption than other carotenoids(39, 40). A comparison of bioavailability of different provitamin A carotenoids suggested that beta-cryptoxanthin–rich foods had 72.5% higher bioavailability than beta-carotene–sources(41). However, food processing decline b-cryptoxanthin concentrations in foods. for all that, food processing and cooking may increase or decrease the bio accessibility. Many beta-cryptoxanthin–food sources (such as peaches and tangerines) are consumed raw or juiced, but others (such as pumpkin and butternut squash) are added to mixed dishes or bake. (38, 42–44).

Our study showed that riboflavin intakes in the Q2 was associated with sperm count. According to our findings, riboflavin may considered a crucial component of the antioxidant defense system of human body and riboflavin deficiency could impair the oxidant/antioxidant balance(45). Another mechanism may be related to role of flavin adenine dinucleotide (FAD) as a crucial cofactor in enzymatic redox reactions, that are performed in cellular metabolism and homeostasis(46). disturbance of flavin homeostasis in humans has been associated with several diseases, including: cardiovascular diseases, cancer, anemia, abnormal fetal development, and neuromuscular and neurological disorders(47); however, the connection between FAD homeostasis and fertility is not investigated(46).

For other nutrients such as Beta-carotene, lutein, zeaxanthin, vitamin C, vitamin b6, vitamin b12, vitamin D, vitamin E and folate, we did not find an association with sperm parameters. likewise, a study published in 2005, suggested that folate intake did not improve semen quality in healthy men(31).However, Mendiola et al. in a clinical trial found higher intake of folate in normozoospermia controls(32). On the other hand, in that case–control study, vitamin E intake was not associated with semen quality(32) but Eskenazi et al found that it was associated with sperm motility in healthy men(31).Also Supplementation with vitamin E and selenium was associated with improved sperm quality in infertile men and suggested the beneficial impact of vitamin E on sperm motility(48).

There are several limitations that should mentioned. Similar to other cross-sectional studies, the inherent methodological limitations make it impossible to describe a causal link between dietary antioxidant, vitamin and semen quality. Another concern is that participants may change their diet choices and this might alter the risk estimates.

Conclusion

In conclusion, this study with high sample size, provides important data on the association between dietary intake of antioxidant, vitamin and semen quality. We found that dietary intake of Alpha Carotene, Beta Cryptoxanthin, and Riboflavin are related to semen volume, sperm count and total motility in Iranian infertile men and shows that changing diet quality might have beneficial effects in improvement semen quality and sperm parameters. However, more studies are needed to confirm these relations and provide the evidence needed to exert these findings into clinical practice.

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.

Consent for publication

Not applicable

Availability of data and materials

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

competing interests

The authors declare that they have no competing interests" in this section.

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Authors ‘contributions

FH, RGh: designed research; FH: conducted research; FH, LDM, AJ: provided essential materials; MN: analyzed data; FH: wrote paper; FH: had primary responsibility for final content. The authors read and approved the final manuscript.

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