Food intake and its relationship with semen quality: a case-control study

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Objective: To compare dietary habits in normospermic and oligoasthenoteratospermic patients attending a reproductive assisted clinic.
Design: An observational, analytical case-control study.
Setting: Private fertility clinics.
Patient(s): Thirty men with poor semen quality (cases) and 31 normospermic control couples attending our fertility clinics.
Intervention(s): We recorded dietary habits and food consumption using a food frequency questionnaire adapted to meet specific study objectives. Analysis of semen parameters, hormone levels, Y microdeletions, and karyotypes were also carried out.
Main Outcome Measure(s): Frequency of intake food items were registered in a scale with nine categories ranging from no consumption to repeated daily consumption.
Result(s): Controls had a higher intake of skimmed milk, shellfish, tomatoes, and lettuce, and cases consumed more yogurt, meat products, and potatoes. In the logistic regression model cases had lower intake of lettuce and tomatoes, fruits (apricots and peaches), and significantly higher intake of dairy and meat processed products.
Conclusion(s): Frequent intake of lipophilic foods like meat products or milk may negatively affect semen quality in humans, whereas some fruits or vegetables may maintain or improve semen quality. (Fertil Steril® 2009; 91:812–8. ©2009 by American Society for Reproductive Medicine.)

Key Words: Semen quality, food frequency, xenobiotics

Several studies have suggested that human semen quality and fecundity have been declining during the past decades (1–13). Nevertheless, other works have obtained contradictory results (14–16), indicating that these changes have not taken place homogeneously in the world. Geographical differences in semen quality also support the fact that semen quality may have declined only in some areas (17–20). Changes in seminal samples are recent (1–4), and may be related to environmental or occupational pollutants, changes in lifestyles, exposure to toxins, or dietary habits (21, 22).

Volatile organic compounds (23), certain halogenated compounds (24), several heavy metals (25, 26) or xenoestrogens like some polychlorinated biphenyls (27–29), organochlorine compounds (pesticides) (30–32), and phthalate esters (33) may compromise reproductive male function.

A recent study carried out by Swan et al. (34) suggests that maternal beef consumption, and possibly xenobiotics (anabolic steroids) in beef, may alter a male fetus' testicular development in utero and adversely affect his reproductive capacity. Sperm concentration was inversely related to the mother's beef intake per week. In sons of "high beef consumers" (>7 beef meals/week), sperm concentration was 24.3% lower than in the men whose mothers ate less beef (34, 35).

It is speculated that there may be a causal link between male reproductive anomalies (hypospadias, cryptorchidism) (36, 37) and the global decrease in sperm counts (1) related to the marked increase in our diet of phytoestrogens by the Western adoption of a fast food culture (38, 39).

Although, traditionally, estrogen (E) was perceived as having a minor role in male reproduction, it is now clear that E have a major role in male gonadal development, spermatogenesis, and fertility (40). Evidence coming from animal models (41) and human studies have shown that increasing levels of phytoestrogen intake can disrupt both the normal development and the function of the male reproductive system

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(42). We found only one report in which adult men were given phytoestrogen supplements (isoflavone) for 20 days and no effect was observed on semen quality (43).

The aim of the study is to compare dietary habits in normospermic and oligoasthenoteratospermic patients attending a reproductive assisted clinic.

MATERIALS AND METHODS

Design and Patients

The present work is methodologically designed as an analytical observational case-control study. The patients were men of couples attending our fertility clinics of the Instituto Bernabeu (IB) Cartagena, Elche, and Alicante (southeast of Spain), between 2005 and 2007. Two groups were formed on the basis of seminal quality and following World Health Organization (WHO) criteria (44): [1] cases (n = 30) composed of men with severe or moderate oligozoospermia ($<5 \times 10^6$ million of sperms/mL or between 5 and 20 million of sperms/mL, respectively) and severe teratozoospermia (<6% normal forms, strict criteria according to Kruger et al.) (45), and [2] controls (n = 31) composed of normospermic patients ($\geq 20 \times 10^6$ million of sperms/mL, $\geq$50% motile sperm, and $\geq$14% normal forms, strict criteria). An additional 10 patients and 12 controls, who were invited to participate, refused to be included in the study. Therefore, there were no significant differences between the refusal rates in cases and controls. Subjects provided at least two semen samples after an abstinence period of 3–5 days. Analyses of samples were done following WHO criteria (44). We excluded patients who showed a clinical history of varicocele, cryptorchid or endocrine hypogonadism (abnormal hormonal levels), chemotherapy or radiotherapy, and anomalies in the karyotype, or presented Y chromosome microdeletions. The mean body mass index (BMI) for cases was 23.2 (95% confidence interval [CI] 22.8–23.6) and for controls 23.5 (95% CI 23.1–23.9). Only two cases and two controls had BMI more than 25 kg/m^2 and all of them were less than 26 kg/m^2. This study was approved by the Institutional Review Board (IRB) of our clinics and patients were included in the study after giving informed written consent.

Questionnaire

All patients were interviewed face-to-face by the same professional before or after the first semen sample was obtained. Men were asked about the average frequency of consumption of 96 food items during the past year (46). Food frequency questionnaire was designed in five blocks, each of them addressing a general group of foods: [1] dairy products, [2] eggs, red and pork meat, chicken, cold meats, meat processed products, organs, fish, and shellfish, [3] raw or cooked vegetables, potatoes, legumes, and fruits, [4] vegetable oils and sweets, and [5] alcoholic and nonalcoholic drinks. Frequency of food consumption was registered in a scale with nine values ranging from no consumption to repeated daily consumption. The specific categories were: [1] never or less than once a month, [2] 1–3 times per month, [3] once per week, [4] 2–4 times/week, [5] 5–6 times/week, [6] once daily, [7] 2–3 times/day, [8] 4–5 times/day, and [9] 6 or more times/day. The questionnaire has been adapted from the Food Frequency Questionnaire developed in the United States (46) and adapted and validated in Spain (47). Administration of the questionnaire took an hour, on average. All questionnaires were completed by the same interviewer. A different questionnaire recorded information on current environmental and lifestyle exposures (e.g., toxic habits, house environment, hobbies, daily clothes, underwear).

Statistical Analysis

Means of intake frequencies for the different food items in cases and controls were compared using nonparametric methods (Mann-Whitney *U*). Odds ratios (OR) and 95% CI were used to explore differences in lifestyle or other exposures. We used multiple logistic regression model for certain analyses. Only food items that were statistically significant in the crude analyses were included in the stepwise logistic regression model. Significance level for all tests was set at $P \leq .05$. Analyses were performed using the statistical package SPSS 13.0 (SPSS Inc., Chicago, IL).

RESULTS

Table 1 shows the semen parameters and hormone levels between the cases and controls. Hormonal values were normal and similar between the two groups. There were no significant differences between the two semen samples within groups. As expected, due to study's methodological design, semen parameters (except seminal volume) were significantly lower in cases than in controls ($P \leq .001$). Table 2 provides a summary of lifestyle and toxin or pollutant exposures in the two groups. No statistically significant differences were found between cases and controls. Table 3 summarizes the differences in average food intakes between the two groups for selected food items. Cases presented a higher intake of yogurt, meat products, and potatoes ($P \leq .05$). Controls had significantly higher intakes of skimmed milk, shellfish, raw or cooked vegetables, apricots and peaches, and sweets. Other food items did not show statistically significant differences between the groups. In a logistic regression model, cases had lower intake of lettuce and tomatoes (OR = 0.4; 95% CI 0.2–0.8), fruits (apricots and peaches) (OR = 0.3; 95% CI 0.1–0.6), and a significantly higher intake of dairy products (OR = 3.1; 95% CI 1.1–8.5) and meat processed foods (OR = 2.6; 95% CI 1.2–5.4).

DISCUSSION

Our study suggests that semen quality may be influenced by food intake. Men with poor semen quality had a more frequent intake of some food items that may adversely affect semen quality or that act as carriers of deleterious products to

TABLE 1

Sperm quality and hormonal levels.

Variables	Cases (n = 30) 1st sample (mean ± SD)	Cases (n = 30) 2nd sample (mean ± SD)	Cases (n = 30) Average[a] (mean ± SD)	Controls (n = 31) 1st sample (mean ± SD)	Controls (n = 31) 2nd sample (mean ± SD)	Controls (n = 31) Average[a] (mean ± SD)	*P* value
Semen samples							
Volume (mL)	3.9 ± 1.3	3.7 ± 1.1	3.8 ± 1.2	3.6 ± 1.0	3.4 ± 1.7	3.5 ± 1.4	.376
Concentration (10^6/mL)	3.2 ± 2.3	3.7 ± 1.8	3.3 ± 4.1	41.7 ± 15.6	37.4 ± 13.6	39.5 ± 14.6	<.001
Sperm motility (grade a+b)	29.2 ± 19.8	25.5 ± 17.4	27.4 ± 18.6	51.1 ± 10.3	53.3 ± 14.3	52.2 ± 12.3	<.001
Percent normal morphology[b]	3.6 ± 1.3	3.8 ± 1.7	3.7 ± 1.5	23.4 ± 4.9	21.1 ± 4.1	22.3 ± 4.5	<.001
Hormonal levels							
FSH	6.4 ± 2.1			6.5 ± 1.4			.717
LH	4.2 ± 1.2			4.1 ± 1.4			.815
T	5.3 ± 1.6			5.4 ± 1.3			.799

[a] No significant differences were found between the first and second samples between cases or controls.
[b] Strict criteria (54).

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the reproductive system. Our results are consistent with poor semen quality associated with a higher intake of products that may incorporate xenobiotics, mainly xenoestrogens or certain anabolic steroids (34, 39). The use of these compounds in the food industry results in an increased total level of xenoestrogens and sex steroids in processed foods, such as meat or milk, whose intake contributes significantly to daily exposures. Xenoestrogens are highly lipophilic substances that can accumulate in fat-rich foods like meat or milk, and are suspected as partially responsible for the decline in semen quality. They include polychlorinated biphenyls (28, 29), organochlorine compounds (pesticides) (31, 32), and phthalate esters (33). In a study, Rozati and colleagues (28) found that total motile sperm counts in infertile men were inversely proportional to their xenoestrogen concentrations, which also were significantly lower in the controls.

In our study the association with poor semen quality was observed in meat processed foods (sausages and others) with especially high saturated fat content. The control group had a significantly higher intake of skimmed milk and a lower intake of all four dairy products, and consequently, a possibly lower intake of products containing lipophilic substances like xenoestrogens (38, 39).

Other food items were associated with a better semen quality. The control group had a higher intake of lettuce and tomatoes, and some fruits. These findings are consistent with a higher intake of antioxidants and micronutrients, which would have a positive influence in maintaining or improving semen quality in this group. It is known that human spermatozoa generate reactive oxygen species (ROS) in physiologic amounts (48), but an excessive production causes impairment of seminal quality by many mechanisms (49). In fact, a higher antioxidant diet has been associated with higher sperm numbers and motility in healthy nonsmoking men (50). Oxidative stress associated with increased ROS generation and reduced antioxidant capacity is negatively correlated with sperm concentration and motility in infertile men (51) and recently, with morphology (52). In the same recent study Agarwal et al. (52) found that among the male factor infertility patient groups, mean ROS levels were significantly higher in the subgroup of those who had abnormal sperm parameters compared with male factor infertility patients with normal sperm parameters. There are several published studies in the review by Agarwal (53) where the antioxidant therapy has improved certain seminal parameters in male factor infertility patients, and in its conclusions summarized that rationale and evidence supporting the use of antioxidants in infertile male patients with elevated oxidative stress do exist. However, those foods items could also show a larger presence of xenoestrogens like pesticides (28), but their beneficial effects would outweigh the negative consequences.

We have only found a few references in the scientific literature about observational studies relating semen quality and food intake. A poster communication presented to the American Society of Reproductive Medicine (ASRM) 62nd Annual Meeting in New Orleans in 2006 found that the proportion of men with low intake of fruits and vegetables (<5 servings/day) was greater among infertile men than in controls (83% vs. 40%, *P*=.0036). In that study, men with

TABLE 2

Comparison of general characteristics in cases and controls.

Variables	Cases (n = 30)		Controls (n = 31)			
	n	%	n	%	OR	95% CI
Age (y, mean ± SD)	34.2 ± 3.7		32.8 ± 3.9		NS	
Clinics						
IB Alicante	14	46.7	18	58.1		
IB Cartagena	13	43.3	13	41.9		
IB Elche	3	10	—			
Current smoker	8	26.7	11	35.5	0.66	0.22–1.97
No. of years smoking (mean ± SD)	18.8 ± 4.1		15.8 ± 3.5		NS	
Ever smoking	11	36.7	11	35.4	1.06	0.37–2.99
Passive smoking at home	1	3.3	—			
Passive smoking at work	5	16.7	4	12.9	1.35	0.33–5.60
Current alcohol drinking	14	46.7	18	58.1	0.63	0.23–1.74
Nail biting	7	23.3	11	35.5	0.55	0.18–1.70
Self car repair	5	16.7	4	12.9	1.35	0.33–5.60
Hobbies or handicrafts with toxic products	6	20	2	6.5	3.62	0.67–19.63
Recently reformed home	6	20	4	12.9	1.47	0.47–6.60
Lead pipeline at home	1	3.3	4	12.9	0.23	0.02–2.21
Living near pollutant areas	3	10	2	6.5	1.61	0.25–10.40
Heavy traffic near home	13	43.3	12	38.7	1.21	0.44–3.36
Use of synthetic clothes	12	40.0	15	48.4	1.41	0.51–3.88
Fitted trousers	14	46.7	16	51.6	0.82	0.30–2.24
Fitted underwear	26	86.7	25	80.7	1.56	0.39–6.19
Cell phone in pocket	26	86.7	29	93.5	0.45	0.08–2.65

Note: No significant differences were found in any of the variables.
CI = confidence interval; NS = not significant; OR = odds ratio.

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the lowest intake of dietary antioxidants had the lowest sperm motility (54). From the same research group, Song and colleagues (55), in another communication, described beneficial effects of dietary intake of plant phytoestrogens on semen parameters and sperm DNA integrity in infertile men. They concluded that population-based studies and basic research are both needed to confirm and clarify the mechanism of the effects of phytoestrogens on sperm physiology. A recent oral communication was presented at the ASRM 63rd Annual Meeting in Washington in 2007 by Chavarro and colleagues (56), of a cross-sectional study exploring the association of soy foods and soy isoflavone intake with semen quality parameters. They suggest that higher intake of these foods was associated with lower sperm concentration.

Some possible limitations of our study design should be discussed. The main concern with our study refers to sample size, which would specially affect the power to detect differences between the two groups. However, sample size would not affect the validity of the associations observed, but we may have failed to observe other true differences between the groups. Selection of controls is an important concern in case-control studies (57). The main criteria for selecting appropriate controls are to ensure comparability between the two groups. Our controls would have been cases if they had had poor semen quality, as they both were recruited in the clinics.

The other major concerns with case-control studies are information bias, specially recall bias, and confounding (57). Recall bias is certainly one of the most serious concerns in case-control studies, and our study may not be an exception. Recall bias would be a concern if recall of diet were different among cases and controls. In our study, both cases and controls were patients attending the fertility clinic for couple infertility. Two semen samples were requested of all men seeking fertility treatment. The final diagnosis of semen quality is not given until the results of the second sample are available. Interviews and questionnaires were applied at the visit made by patients to give the second semen sample, and therefore before those final results were available. Therefore, it is unlikely that knowledge of semen quality might have influenced differentially the recall of cases and controls. All interviews were made under similar circumstances and by the same trained person.

TABLE 3

Average food intake of selected food items in cases and controls.

Variables	Cases (n = 30) (mean ± SD)[a]	Controls (n = 31) (mean ± SD)[a]	*P* value
Whole milk	3.13 ± 2.49	2.61 ± 2.38	.407
Semi-skimmed milk	2.53 ± 3.39	1.97 ± 2.01	.320
Cheese	4.17 ± 1.49	3.71 ± 1.64	.259
Yogurt	3.4 ± 1.57	2.48 ± 1.59	.016
All 4 dairy products[b]	3.3 ± 1.57	2.7 ± 1.19	.03
Skimmed milk	1.50 ± 1.38	3.03 ± 2.61	.013
Eggs	3.43 ± 0.93	3.26 ± 0.99	.482
Red meat	2.77 ± 0.90	3.03 ± 0.88	.247
Pork meat	2.73 ± 1.02	2.45 ± 1.09	.301
Chicken	3.37 ± 0.62	3.35 ± 0.88	.950
Cold meats	4.27 ± 1.26	4.06 ± 1.55	.578
Organs	1.10 ± 0.31	1.00 ± 0.00	.073
Fish	2.33 ± 1.12	2.55 ± 0.96	.425
Legumes	3.20 ± 0.89	2.97 ± 0.91	.318
Vegetable oils	6.50 ± 1.30	6.90 ± 1.23	.880
Nonalcoholic drinks	3.63 ± 1.99	3.03 ± 1.54	.191
Coffee	5.13 ± 2.16	5.16 ± 2.10	.959
Alcoholic drinks	3.40 ± 1.65	3.32 ± 1.56	.851
Meat processed products	2.80 ± 1.13	2.13 ± 1.26	.012
Potatoes	3.43 ± 0.94	2.74 ± 1.39	.028
Fruits (apricots and peaches)	1.73 ± 1.30	2.23 ± 1.49	.021
Shellfish	1.73 ± 0.74	2.19 ± 0.48	.006
Raw vegetables (lettuce and tomatoes)	4.55 ± 1.35	5.65 ± 1.27	.002
Lettuce	4.50 ± 1.37	5.61 ± 1.43	.004
Tomatoes	4.60 ± 1.38	5.68 ± 1.19	.002
Sweets	2.57 ± 1.30	3.68 ± 1.92	.027

[a] Mean values represent the average yearly consumption of specific food items, with the following correspondence between numeric values and categories of consumption: "1" = never or less than once a month; "2" = 1–3 times per month; "3" = once per week; "4" = 2–4 times/week; "5" = 5–6 times/week; "6" = once daily; "7" = 2–3 times/day; "8" = 4–5 times/day, and "9" = 6 or more times/day.

[b] "Dairy products" includes yogurt, whole milk, cheese, and semi-skimmed milk. There was a significantly and negative correlation between intake of these products and intake of skimmed milk ($r = -0.6$, $P < .001$).

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A different consideration refers to the temporal relation between possible exposures and the impact of the reproductive system that resulted in low seminal quality. The association we are observing could be due to an actual effect of the current diet on seminal quality or the reflection of the consequences of exposure at a younger age. Having had a higher intake of some food products in the past at a younger age may also have had a permanent effect on semen quality (34, 39).

Finally, the case-control study, as an observational design, does not allow us to infer causality in the associations (57). The link between xenobiotics and other exposures on diet and semen quality is controversial (58, 59). Therefore we concur that more research is needed to check the influence and effect of food intake and other exposures throughout the life cycle, testing the impact of prenatal and perinatal exposures, as well as during infancy, childhood, puberty, and adulthood on reproduction and fertility in men. Ideally, a prospective design would be more suitable to address the effect of possible exposures along each stage of a patient's life cycle.

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