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Exploring the Link Between Global Diet Quality Score and Sperm Parameters in Infertile Men: A Cross-Sectional Study

Marziyeh Kharrazi; MSc Candidate[1], Bibi Zainab Hossaini; BSc[2], Ali Kosari; MSc Candidate[1], Zahra Darabi; PhD[1*] & Mahdieh Hosseinzadeh; PhD[3, 4]

[1] Nutritional Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran; [2] Department of Nutrition Sciences, Varastegan Institute for Medical Sciences, Mashhad, Iran; [3] Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran; [4] Research Center for Food Hygiene and Safety, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

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Corresponding author:
z,darabi91@yahoo.com
Nutritional Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran.

Postal code: 6819789741
Tel: +98 066-33302033

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ABSTRACT

Background: In examining the causes of a couple's infertility, the male factor generally accounts for about 50%. According to the World Health Organization (WHO), an infertile man is defined as someone whose sperm cannot fertilize a healthy egg after at least one year of regular, unprotected sex. Diet is known to be one of the most important factors affecting male fertility. Therefore, the purpose of this study was to examine the relationship between the Global Diet Quality Score (GDQS) and sperm quality. **Methods:** This cross-sectional study involved 218 infertile men aged between 20 and 50 who visited an infertility referral clinical and research center. A 168-question food frequency questionnaire (FFQ) was used to evaluate their food intake. The GDQS was calculated from the sum of scores across 25 food groups, with scores ranging from 0 to 49. To assess the relationship between GDQS and sperm parameters, logistic regression was used to account for potential confounding factors. **Results:** The results of this study demonstrated that in the unadjusted model, higher adherence to the GDQS was associated with lower odds of low sperm concentration, though this association was not statistically significant (OR: 0.60; 95% CI: 0.29–1.20; P=0.15). This association was attenuated and no longer significant after adjusting for confounding factors, with no significant associations observed for other sperm parameters in either crude or adjusted models (all P>0.05). **Conclusion:** Future research requires large-scale prospective cohorts, clinical trials, and more detailed dietary pattern assessments to better understand the diet-fertility relationship.

Introduction

Infertility issues are on the rise globally, impacting many couples (Vander Borght and Wyns, 2018, Wasilewski *et al.*, 2020). It is a condition affecting the male or female reproductive system, and is characterized by the inability to achieve pregnancy after 12 months or more of regular, unprotected intercourse (de Vries *et al.*, 2024). Moreover, infertility affects about 15% of

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the world's population (Sun *et al.*, 2019). Recent findings indicate that about 186 million individuals and 48 million couples worldwide experience infertility (Almabhouh and Singh, 2022, Annapurna and Pattnaik, 2022, Inhorn and Patrizio, 2015). A meta-analysis published in 2019 reports a 7.88% prevalence rate of infertility in Iran (Naz *et al.*, 2019). Some causes of male infertility include obesity, genetic factors, lifestyle choices, genital infections, reproductive tract obstructions, abnormalities in sperm parameters (motility, count, and morphology), testicular torsion or trauma, testicular varicocele, erectile disorders, hypogonadotropic hypogonadism, and chronic systemic disorders (Vander Borght and Wyns, 2018, Wasilewski *et al.*, 2020).

Research suggests that diet is one of the most important modifiable factors affecting male fertility (Cristodoro *et al.*, 2024, Salas-Huetos *et al.*, 2017b, Salas-Huetos *et al.*, 2018b). A healthy diet has been linked to improved fertility in both men and women (Cristodoro *et al.*, 2024). Observational studies have found a link between dietary patterns, food, nutrients, and sperm quality. Results of previous studies have also shown that a healthy dietary pattern may improve the quality of men's sperm parameters (Salas-Huetos *et al.*, 2017b, Salas-Huetos *et al.*, 2018b). A meta-analysis indicates that dietary patterns characterized by a high intake of fruits and vegetables, plant protein, legumes and nuts, moderate consumption of low-fat dairy products, and reduced animal protein intake, positively influence sperm concentration, total sperm count, and progressive sperm motility in males (Cao *et al.*, 2022). Evidence suggests that diets rich in fruits, vegetables, fish, whole grains, and low-fat dairy products are associated with better semen quality, whereas dietary patterns high in processed meats, refined grains, sweets, and sugary beverages have a detrimental effect on sperm parameters (Eslamian *et al.*, 2015, Soltani *et al.*, 2025).

Given the growing evidence linking diet to reproductive health, there is a need for a practical tool to assess overall dietary quality. The Global Diet Quality Score (GDQS) is a standardized, food-based metric developed to assess overall dietary quality across diverse populations and settings. It captures two key dimensions of diet: nutrient adequacy and risk of non-communicable diseases (NCDs) (Bell *et al.*, 2025). The GDQS serves as a validated metric that assesses nutritional adequacy and predicts the risk of major non-communicable diseases, and can serve as a universal and practical tool to assess diet quality globally, as it is designed to be simple, timely, and cost-effective for tracking both nutritional deficiency and NCD risks in diverse settings (Bell *et al.*, 2025, Mehrabani *et al.*, 2025). Several studies have confirmed its relationship with various health outcomes in different communities(Angulo *et al.*, 2021, He *et al.*, 2021, Satija *et al.*, 2017, Seidelmann *et al.*, 2018). A 20-year study conducted in a Mediterranean population found that higher diet quality (GDQS) and increased consumption of healthy foods (GDQS+) are associated with a reduced risk of cardiovascular diseases and type 2 diabetes. These findings suggest that focusing on increasing the intake of healthy foods in the diet is more important for the prevention of cardiovascular diseases and type 2 diabetes (Damigou *et al.*, 2023).

In addition to these findings, more recently, multiple investigations have indicated a positive association between semen quality and dietary patterns characterized by high intakes of fish, shellfish, seafood, poultry, cereals, vegetables, fruit, and low-fat dairy products (Ricci *et al.*, 2019, Salas-Huetos *et al.*, 2017a). Conversely, dietary patterns abundant in processed meats, soy, potatoes, full-fat dairy products, coffee, alcohol, sugary beverages, and sweets appear to have a detrimental effect on semen quality (Salas-Huetos *et al.*, 2017a, Torres-Arce *et al.*, 2021). The GDQS covers 25 food groups, promoting the consumption of whole grains, orange vegetables, fruits, fish, chicken, eggs, legumes, nuts, liquid oils, and low-fat dairy products. It also emphasizes reducing intake of red and processed meats, sweets, sugar sweetened beverages, refined grains, fried foods, and salt (Bromage *et al.*, 2021). Despite the well-documented role of diet in male fertility and the validation of GDQS as a comprehensive dietary

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assessment tool, its direct association with sperm parameters in infertile men has not yet been investigated. Therefore, this study aims to address this gap by examining the relationship between adherence to the GDQS and sperm quality in a sample of Iranian infertile men.

Materials and Methods

Study population

This cross-sectional study was conducted among infertile men who visited the research and clinical center for infertility. Eligible participants included men aged 20 to 50 years with any abnormalities in sperm morphology, motility, or concentration. Exclusion criteria encompassed chronic illnesses, azoospermia, genetic disorders, a history of vasectomy, varicocele, macroorchidism, and cryptorchidism. Additionally, individuals who failed to respond to more than 35 items on the food frequency questionnaire or reported energy intake outside the range of 800 to 4200 kcal were excluded from the study.

Sample size calculation

The sample size was measured based on a 95% confidence interval and 80% test power and according to the correlation coefficient (r=0.26) between WC and total sperm count in a study by Fejes *et al*. (Fejes *et al.*, 2005) according to the following equation: $N=[(Z\alpha+Z\beta)/C]^2+3]$. The standard normal deviated for Zα=1.9600. Further, the standard normal deviated for Zβ=0.8416 and C=0.5. Participants were selected using convenience sampling. Ultimately, after applying the inclusion and exclusion criteria and removing incomplete data, 218 men were included in the final analysis.

Dietary intake and physical activity

Data on dietary intake were collected through face-to-face interviews conducted by trained dietitians using a validated semi-quantitative FFQ with 168 food items (Eghtesad *et al.*, 2025). Participants were asked about the frequency of consumption of each food item over the preceding year. The portion sizes and items reported in household measures were converted to grams following guidelines from Nutritionist 4 scales (Rohde *et al.*, 2019). Then, the dietary intake for each participant was quantified in grams per day. To assess energy, macronutrient, and micronutrient intake, the authors referenced a food ingredients table tailored for Iranian foods. Additionally, daily physical activity was evaluated using a brief version of the International Physical Activity Questionnaire (IPAQ), with results expressed in MET-hours per week (Campos-Perez *et al.*, 2020).

GDQS index

Globally, GDQS serves as a validated metric that assesses nutritional adequacy and predicts the risk of major non-communicable diseases (Bromage *et al.*, 2021). The scoring system is based on the consumption amounts (in grams per day) of 25 specific food groups, categorized into three or four distinct groups. The GDQS includes 16 healthy food groups (including citrus fruits, deep-orange fruits and vegetables, dark-green leafy vegetables, cruciferous vegetables, legumes, nuts and seeds, whole grains, fish and shellfish, poultry, eggs, and low-fat dairy), seven unhealthy food groups (including processed meat, refined grains and baked goods, sweets and ice cream, sugar-sweetened beverages, juice, white roots and tubers, and purchased deep-fried foods), and two additional unhealthy food groups (high-fat dairy and red meat) that are considered detrimental when consumed in excess. The total possible score ranges from 0 to 49 points. For the healthy food categories, higher scores are awarded for greater intake, whereas for the unhealthy categories, higher scores are associated with lower consumption levels. In the case of unhealthy foods that are harmful when consumed excessively, scores increase up to a certain threshold, beyond which no further points are granted (Bromage *et al.*, 2021).

Collection and analysis of semen samples

Semen samples were obtained through masturbation in a designated room adjacent to the laboratory and were maintained at a temperature of 37 °C. Participants were instructed to abstain from ejaculation for a minimum of 48 hours prior to sample collection. The analysis of semen was

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performed in accordance with the guidelines established by the WHO (Björndahl and Brown, 2022). Then, key sperm parameters, including sperm concentration (measured in millions per milliliter), motility, viability, and normal morphology, were evaluated based on a count of 200 spermatozoa from each sample. Sperm concentration and motility were assessed using a Makler chamber under light microscopy (Olympus Co., Tokyo, Japan). Viability was then determined using Eosin staining, while morphological assessment was conducted utilizing Papanicolaou staining techniques.

General, medical, and anthropometric measurements

General information, including education level, economic status, and employment details, was gathered through personal interviews. Anthropometric measurements were also taken using standardized methods. Then, body weight was measured with an accuracy of 100 grams using a Seca scale. Height was recorded with a tape measure while the individual stood without shoes, ensuring that the shoulders were in a neutral position, also utilizing a Seca scale. After that, body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters (kg/m^2). Waist circumference was also measured to an accuracy of 0.1 cm using a tape measure, ensuring no pressure was applied to the body surface. This measurement was taken at the midpoint between the lower rib and the upper part of the pelvis at the end of a normal exhalation. In cases where it was difficult to identify the narrowest point of the waist, measurements were taken just below the last rib, as this area is typically the narrowest between the iliac crests and lower ribs (Chaves and Reis, 2019). Finally, hip circumference was measured with a tape measure to an accuracy of 0.1 cm, taken in a standing position without any additional clothing covering the area. This measurement was conducted at the widest point of the hip bone, corresponding to the largest circumference of the thigh.

Ethical considerations

The study protocol received approval from the ethics committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran (Ethics ID: IR.SSU.SPH.REC.1402.059). Informed consent was also obtained from all participants prior to their enrollment in the study.

Data analysis

After entering the data into SPSS software version 26, to assess differences in general characteristics across tertiles, the authors employed one-way ANOVA for continuous variables and the chi-square test for categorical variables. Dietary intakes among the tertiles were analyzed using ANOVA. To examine the association between adherence to the GDQS and sperm parameters, the authors utilized multivariate logistic regression in both crude and adjusted models.

Results

Characteristics of the study population

Characteristics of the participants are presented in **Table 1**. The mean age of the participants was 33.8±5.7 years.

Table 1. Descriptive characteristics of the study population (N=218).

Variable	
Quantitative	**Mean ± SD**
Age (y)	33.8 ± 5.7
Body mass index (kg/m^2)	25.7 ± 4.8
Fat mass (%)	22.9 ± 7.9
Waist circumference (cm)	93.8 ± 12.4
Visceral fat (%)	8.4 ± 4.3
Sperm concentration	36.2 ± 28.5
Sperm motility	
Progressive	30.8 ± 15.2
Nonprogressive	10.8 ± 6.1
Immotile	57.8 ± 16.4
Sperm. morphology	2.6 ± 1.7
Physical activity (met)	43.9 ± 4.9
Qualitative	**n (%)**
Smoker	
Yea	72(33.1)
No	146 (66.9)
Education level	
High school	33(15.1)
Diploma	131(60.1)
Bachelor	44 (20.2)
Master's degree and higher	10 (4.6)

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Dietary intakes of participants

Table 2 presents the mean and standard deviation of dietary component intakes across tertiles of the GDQS. Participants in the highest GDQS tertile (T3) showed significantly higher intake of energy, fruits, vegetables, nuts, and legumes compared to those in the lowest GDQS tertile (T1). There were no significant differences in the intake of whole grains, Polyunsaturated fatty acids (PUFA), and monounsaturated fatty acids (MUFA) between the two tertiles.

Table 2. Dietary intakes of participants across tertiles of Global Diet Quality Score (GDQS).

Variables	Tertiles of GDQS			P-value[a]
	T1	T2	T3	
Energy (kcal)	2962.32±702.74[b]	3106.85±627.24	3393.14±467.87	<0.001
Fruits (g)	392.58±392.05	492.63±438.70	695.48±375.12	0.000
Vegetables (g)	100.25±138.91	116.08±88.46	163.92±117.18	0.004
Nuts (g)	10.25±12.28	18.98±22.39	20.22±21.57	<0.01
Legumes (g)	38.88±31.81	47.14±39.42	64.85±30.87	<0.001
Whole grain (g)	92.11±108.26	112.56±101.97	105.39±96.67	0.472
PUFA (g)	26.18±15.87	25.17±11.02	24.60±14.56	0.792
MUFA (g)	31.58±17.51	28.61±12.35	32.05±15.74	0.335

*[a]: obtained from one-way ANOVA; [b]: Mean±SD; **PUFA**: Polyunsaturated fatty acids; **MUFA**: Monounsaturated fatty acids.*

Association between adherence to GDQS and odds of decreased sperm quality

Crude and multivariate-adjusted odds ratios for decreased sperm quality based on tertiles of GDQS are listed in **Table 3**. The results of this study demonstrated that in the unadjusted model, higher adherence to the GDQS was associated with a lower odds of low sperm concentration (OR: 0.60; 95% CI: 0.29–1.20; *P*=0.15). The significant association was no longer observed after adjusting for confounding factors, including BMI, total energy intake, physical activity, age, fat mass, waist circumference, visceral fat, tobacco and education. Furthermore, no significant associations were found between GDQS exposure and the odds of low semen volume, low sperm morphology, and low progressive/non-progressive motility in either crude or adjusted models. These findings from this observational study suggest a lack of statistically significant associations between overall GDQS exposure and the odds of decreased sperm quality across the examined semen parameters.

Discussion

While previous studies have focused on various nutritional aspects related to sperm quality parameters, this research examines the association between adherence to the GDQS and sperm parameters among Iranian adults in a Middle Eastern country, which has received less attention to date. The authors observed a non-significant association between adherence to GDQS and sperm parameters Accordingly, a cross-sectional study conducted on Iranian infertile men by Leilami *et al*. found no significant association between the Healthy Eating Index and most of the semen parameters after adjustment for confounders, except for sperm concentration; this highlights that the relationship between overall dietary quality and male fertility can be complex and may not always show universal significant associations across all parameters or populations (Leilami *et al.*, 2022). A study on dietary patterns and semen quality in a university-based cohort by Joseph *et al*. concluded that while a 'Prudent' dietary pattern was linked to higher progressive sperm motility, it showed no significant association with sperm concentration and morphology. Furthermore, a 'Western' dietary pattern was found to be unrelated to conventional semen quality parameters (Joseph, 2021), and the

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following studies report observed effectiveness. The study by Nassan *et al*. investigated a consistent association between healthy dietary patterns and improved semen parameters (Nassan *et al.*, 2018). The result of this study indicated that diets such as the Mediterranean pattern, as well as those rich in seafood, poultry, whole grains, legumes, skimmed milk, fruits, and vegetables, have been linked to enhanced semen quality across various studies conducted in North America, Europe, the Middle East, and East Asia. In contrast, unhealthy dietary patterns characterized by high consumption of fats, red and processed meats, refined grains, sweets, and sugary beverages are associated with lower semen quality (Nassan *et al.*, 2018).

Table 3. Odds ratio of considered sperm disorder across tertiles of Global Diet Quality Score (GDQS) (Multivariable-adjusted odds ratios and 95% confidence intervals).

Variables	Tertiles of GDQS			
	T1	T2	T3	P-value[a]
Low concentration				
Crude	1.00	0.603(0.299-1.216)	0.600(0.295-1.220)	0.15
Adjusted model 1	1.00	0.718(0.342-1.509)	0.360 (0.302-1.440)	0.29
Adjusted model 2	1.00	0.610(0.235-1.586)	0.670(0.250-1.794)	0.42
Low morphology				
Crude	1.00	1.100(0.433-2.793)	0.836(0.340-2.058)	0.69
Adjusted model 1	1.00	1.081(0.394-2.968)	0.620(0.223-1.725)	0.36
Adjusted model 2	1.00	0.983(0.250-3.857)	0.675(0.163-2.791)	0.58
Low_progressive_nonprogressive_motility				
Crude	1.00	0.658(0.329-1.316)	0.768(0.384-1.539)	0.45
Adjusted model 1	1.00	0.645(0.307-1.354)	0.938(0.438-2.009)	0.86
Adjusted model 2	1.00	0.827(0.325-2.102)	0.864(0.324-2.308)	0.77
Low volume				
Crude	1.00	1.331(0.400-4.431)	1.055(0.289-3.844)	0.93
Adjusted model 1	1.00	1.088(0.309-3.827)	0.810(0.196-3.353)	0.77
Adjusted model 2	1.00	1.156 (0.173-7.719)	1.156 (0.173-7.719)	0.88

[a]*: Third tertile compared to first tertile;* ***Adjusted model 1****: Adjusted for Body Mass Index, Total energy intake, physical activity;* ***Adjusted model 2****: adjusted for body mass index, total energy intake, physical activity, age, fat mass, waist circumference, visceral fat, tobacco and education.*

A study conducted by Mahmoud Benatta *et al*. revealed that epidemiological observations consistently demonstrate an association between low-quality sperm parameters and higher intake of red meat, processed meat, organ meat, and full-fat dairy. Conversely, improved semen parameters were observed in subjects consuming a healthy diet rich in fruit, vegetables, whole grains, and fish (Benatta *et al.*, 2020). Also. the study of Qostingh *et al*. examined the effect of dietary patterns on sperm quality. The results indicated that low intake of high-fat dairy products, sweets, and processed meats, combined with high consumption of folate-rich foods such as fruits and vegetables, is associated with better sperm quality. Additionally, a high intake of fruits, vegetables, fish, and whole grains is linked to a reduction in sperm DNA damage (Oostingh *et al.*, 2017). In these studies, different dietary quality indicators have been utilized, including the Healthy Diet Score, Healthy Eating Index, Alternative Healthy Eating Index, and various adaptations of the Mediterranean diet. Despite these differences, a common finding is that diets rich in fruits, vegetables, legumes, nuts, whole grains, seafood, and fish are linked to improved sperm concentration and motility. Conversely, unhealthy dietary patterns characterized by high intake of fats, red and processed meats, refined grains, sweets, and sugary beverages are correlated with diminished semen quality. Currently, there is a global initiative to encourage a shift towards more plant-based diets

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for better human health (Willett *et al.*, 2019). GDQS comprises 25 food groups, with those selected aligning well with this objective. Among the 17 healthy food groups recommended for inclusion in the diet, only four are of animal origin (Bromage *et al.*, 2021). In contrast, of the nine unhealthy food groups that should be limited, three consist of animal proteins, along with sweets and ice cream, which often contain animal-derived ingredients. Consequently, a high GDQS is indicative of a predominantly plant-based diet (Bromage *et al.*, 2021). The consumption of foods rich in omega-3 fatty acids in the context of GDQS is considered a positive factor, Numerous studies have documented the diverse biological effects of fatty acids on sperm membrane function. Specifically, dietary intake of certain fatty acids has been shown to influence sperm parameters through a variety of mechanisms. The biophysical characteristics of Docosahexaenoic acid (DHA) are likely to enhance the membrane fluidity and flexibility required for sperm tail motility (Calder, 2017). During epididymal maturation, sperm membranes exhibit an increased proportion of PUFAs, particularly DHA (Eslamian *et al.*, 2015). This rise in PUFA levels appears to be largely regulated by local fatty acid metabolism, as indicated by the heightened expression of enzymes involved in this metabolic pathway within the testis and epididymis (Eslamian *et al.*, 2015). Furthermore, trans fatty acids (TFAs) seem to inhibit the activity of these enzymes (Ferramosca and Zara, 2022), which may restrict the incorporation of long-chain PUFAs into sperm membranes, thereby influencing spermatogenesis (Niederberger, 2015). Nuts are energy-rich foods that are primarily composed of MUFAs, with the exception of walnuts, which are predominantly high in PUFAs, along with other essential nutrients (Alasalvar *et al.*, 2020). The enhancements observed in specific seminal parameters may be attributed to their possible influence on sperm DNA fragmentation (SDF) and RNA expression (Salas-Huetos *et al.*, 2018a). It is important to acknowledge that this study found no significant associations between GDQS and sperm parameters, including concentration, morphology, motility, and volume. This may be attributed to several limitations. First, the sample size, although substantial, might have been insufficient to detect subtle association of dietary patterns on sperm quality. Second, the sensitivity of the GDQS assessment, while designed to capture overall dietary quality, may not have been granular enough to identify specific nutrient-related impacts. Third, potential unmeasured confounding factors, such as genetic predispositions or environmental exposures, could have obscured the isolated impact of overall dietary quality. Furthermore, the complex interplay of nutrients and other lifestyle factors may obscure the isolated impact of overall dietary quality. Future studies with larger cohorts, more refined dietary assessments, and comprehensive control for confounders are warranted to further elucidate the relationship between diet and male fertility.

One of the strengths of the present study was a large sample size. Additionally, as the infertility clinic serves as a referral center in Middle Eastern countries, the unique dietary cultures and backgrounds may yield novel insights into the GDQS and its relationship with infertility. Another notable strength is that FFQ was administered by trained interviewers, ensuring that each item was clearly explained to participants before they selected their responses, thus minimizing self-reporting bias. Furthermore, the authors accounted for a variety of potential confounders, including energy intake, BMI, educational level, and physical activity. However, this study also had several limitations. The cross-sectional design restricts our ability to draw causal inferences. Additionally, employing a one-year FFQ may introduce errors in assessing dietary intakes and patterns, potentially leading to measurement errors and misclassification of participants, as well as reporting bias. Therefore, caution should be exercised when generalizing these results.

Conclusion

This cross-sectional study of infertile Iranian men found no significant association between the

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GDQS and sperm parameters after controlling for confounders. While this does not dismiss the importance of healthy eating, it suggests that specific nutrients, genetic factors, and lifestyle may play larger roles in male fertility. Future research requires large-scale prospective cohorts, clinical trials, and more detailed dietary pattern assessments to better understand the diet-fertility relationship.

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Authors' contributions

Darabi Z and Hosseinzadeh M conceived the idea and supervised the study. Hossaini BZ and Kharrazi M wrote the first draft. Kosari A were involved in study analysis. Hosseinzadeh M revised the manuscript. Authors read and approved the final version of the manuscript.

Conflict of interests

The authors declared no conflict of interest.

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