**Associations of dietary inflammatory indices (DII and E-DII) with sperm parameters**

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**Objective:** This study aimed to explore the ambiguous link between dietary inflammatory indices and sperm parameters. Specifically, it investigated the associations between the dietary inflammatory index (DII) and the energy-adjusted dietary inflammatory index (E-DII) with sperm motility, morphology, and count in men undergoing routine semen analysis.

**Methods:** A cross-sectional study was conducted with 144 men enrolled, where semen samples were collected and evaluated according to the 2010 World Health Organization guidelines. Dietary data were gathered using a 147-item semi-quantitative food frequency questionnaire developed by the researchers. Pearson correlation analysis was employed to assess the relationships of the DII and E-DII with sperm parameters.

**Results:** The mean DII and E-DII scores were 1.23±1.1 and 0.49±0.43, respectively. The mean values for sperm motility, morphology, and count were 43.08%±19.30%, 78.03%±26.99%, and 48.12±44.41 million, respectively. Both motility (r=−0.353) and count (r=−0.348) were found to be inversely and significantly correlated with DII. Similarly, Pearson correlation tests revealed strong and significant inverse correlations of motility (r=−0.389) and count (r=−0.372) with E-DII.

**Conclusion:** The findings suggest that a diet with a higher anti-inflammatory potential may be associated with increased sperm count and motility, but not with changes in morphology. Further research is necessary to confirm these findings, elucidate the underlying mechanisms, and identify dietary modifications that could improve male fertility.

**Keywords:** Dietary inflammatory indices; Infertility, male; Nutrition; Semen analysis

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**Introduction**

In recent decades, infertility has emerged as a key global public health issue and an area of focus in professional practice. Estimates indicate that 15% of couples worldwide experience infertility [1], with more than 70 million couples around the world affected by subfertility or infertility [2].

Research suggests that male factors contribute to approximately 30% to 50% of all infertility cases [3,4]. A growing body of research is aimed at identifying modifiable characteristics to improve the management of infertility [5-7]. Male infertility can be caused by genetic abnormalities and medical conditions, but modifiable environmental and lifestyle factors also play a substantial role [3]. Since diet has been implicated as one such modifiable risk factor [4], recent studies have increasingly focused on the potential impacts of dietary patterns and nutrients on semen quality and reproductive health [8,9]. Evidence suggests that changes in one’s diet—a key component of lifestyle—may effectively reduce inflammation and, consequently, the risk of infertility [10]. Separate research has indicated that diet represents a crucial regulator of inflammation and can significantly influence the development and progression of male infertility [11]. Created in 2009 and refined in 2014, the dietary inflammatory index (DII) is used to evaluate the inflammatory potential of various diets [12,13]. The DII incorporates six inflammatory markers: tumor necrosis factor-alpha (TNF-α), C-reactive...
protein (CRP), interleukin 4 (IL-4), IL-6, IL-10, and IL-1β, which are associated with dietary components such as flavonoids, vitamins, macronutrients, minerals, and specific foods [12-14]. The DII can be employed to assess the inflammatory potential of an individual’s diet [12]. Certain foods possess pro-inflammatory or anti-inflammatory properties, influencing various markers of inflammation, including those comprising the DII [15-18]. Furthermore, anti-inflammatory diets and dietary therapies targeting inflammation may improve male reproductive health, which has been shown to relate to DII score. Inflammatory diets have also been linked to lower testosterone levels. However, the relationship between DII score and male reproductive parameters is not fully understood, with conflicting results and limited research exploring this connection [19,20]. To address this gap in knowledge, we conducted a cross-sectional study to examine the correlation between the DII, the energy-adjusted dietary inflammatory index (E-DII), and sperm parameters. Our goal was to assess the impact of inflammatory and anti-inflammatory dietary patterns on male fertility.

Methods

1. Study population

This cross-sectional study included 144 male participants, all of whom had a history of normal reproductive and general health, genetic history, and hormone levels. Physical examination was used to confirm their health status. The study population consisted of men from infertile couples who were referred to the infertility clinic for assisted reproductive treatment due to female factor infertility. Male participants, ranging in age from 20 to 40 years, were recruited at the Kosar Infertility Center in Urmia, Iran, between November 2022 and September 2023 to undergo routine semen analysis. None of the participants were subject to any long-term dietary restrictions. The World Health Organization (WHO) laboratory manual for the examination and processing of human semen was used as the protocol for conducting semen analyses, which included assessments of sperm concentration, motility, and morphology. The study adhered to the ethical guidelines set forth in the Declaration of Helsinki. Written informed consent was obtained from all participants, and the study protocol received approval from the Research Ethics Committee of Urmia University of Medical Sciences, Imam Khomeini University Hospital in Urmia, Iran (ethics code IR.UMSU.HIMAM.REC.1401.056). On the day of their visit, participants underwent a physical examination, provided a semen sample, and completed a food frequency questionnaire (FFQ).

2. Physical examination

Body weight and height were measured for all participants. The body mass index (BMI) was calculated by dividing the weight in kilograms by the square of the height in meters. A single professional examiner performed all physical examinations at our study center. Testicular size was assessed using a Prader orchidometer. The study excluded individuals who exhibited infertility due to conditions such as azoospermia, varicocele, or other abnormalities affecting the scrotum and testicles.

3. Semen collection and analysis

During the designated abstinence period of 3 to 5 days, participants were instructed to collect semen samples through masturbation, using a plastic tube for containment. The use of condoms and lubricants was prohibited. The samples were allowed to liquefy for 45 to 60 minutes before analysis began. Sperm motility was classified under the WHO system, which includes four grades (A, B, C, and D). Ejaculate volume, pH, sperm concentration, total sperm count, and the percentage of motile sperm of each grade were assessed. In brief, a 10-μL aliquot of well-mixed semen was carefully applied to a sterile glass slide pre-warmed to 37 °C. A 22×22 mm coverslip was then placed over the sample to contain and protect it. The slide was positioned on the heated stage of a microscope, also maintained at 37 °C, and promptly examined at 400× magnification. Sperm concentration was determined using a hemocytometer. For morphological analysis, smears were air-dried, fixed, and stained using a Diff-Quick staining kit (Hooshmand Fanavar Tehran Co.), following the manufacturer’s instructions. Reference values for normal sperm morphology were based on WHO criteria [21]. The semen sample was then examined under a microscope at ×200 magnification (Olympus CX21; Olympus). Analyses were performed by a highly experienced technician, and external quality control was consistently applied throughout the study.

4. Dietary inflammatory indices

The DII and the E-DII are innovative tools designed to predict the risk of inflammation associated with a particular diet [13,22]. Scores on the DII can be negative or positive, reflecting an anti-inflammatory or pro-inflammatory dietary pattern, respectively. To calculate DII scores for participants, dietary data were collected using a validated 147-item FFQ [23]. Food intake was quantified through the conversion of all values to grams using Nutritionist-IV software version 7.0 (N-Squared Computing). After participants completed the FFQ, DII scores were calculated using the method developed by Shivappa et al. [13]. This process was based on examination of the effects of 45 nutrients and food components on several inflammatory biomarkers (IL-6, TNF-α, IL-1β, and CRP), as well as the anti-inflammatory markers IL-10 and IL-4. The inflammatory potential of each item was determined based on its capacity to stimulate inflammatory factors, sup-

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press anti-inflammatory factors, or neither. The first step in this process was to calculate the mean and standard deviation for each of the 45 dietary components, using data that were then linked to a globally representative database for the relevant regions. The z-score was obtained by subtracting the “standard global mean” from the “standard report mean” and dividing by the standard deviation. The resulting value was then converted to a percentile to mitigate the right-skewing of the distribution. The final DII score was derived by multiplying the percentile score by the food component’s assigned inflammatory effect score. The FFQ used in this study provides an extensive list of 28 nutritional parameters for use in calculating the DII. These include energy, carbohydrates, total fat, protein, saturated fat, cholesterol, polyunsaturated fatty acids, monounsaturated fatty acids, fiber, vitamins A, C, D, and E, beta-carotene, B vitamins (B1, B2, B3, B6, B9, and B12), iron, magnesium, zinc, selenium, garlic, caffeine, tea, and onion. The E-DII was then calculated by adjusting the DII for a 1,000 kcal intake. A positive correlation is known to exist between DII score and a pro-inflammatory diet, while lower scores suggest an anti-inflammatory diet [13,20,22,24].

5. Statistical analysis
The data were analyzed using SPSS version 23 (IBM Corp.). Descriptive statistics are presented as mean±standard deviation. The Pearson test was employed to assess the correlations of DII and E-DII with sperm motility, morphology, and count. p-values less than 0.05 were considered to indicate statistical significance.

Results
The distribution of food and nutrient intake among the participants was examined. The mean total energy intake was 2,673.55±410.02 kcal. The mean intake values were 82.10±12.70 g for total protein, 367.62±67.29 g for total carbohydrate, and 108.05±24.50 g for total fat. Additional details of dietary intake, including vitamins, minerals, and other nutrients, are presented in Table 1. The mean age and BMI of the participants were 35.01±5.77 years and 25.73±3.32 kg/m², respectively. The analysis yielded significant findings regarding the relationships between dietary inflammatory indices and sperm quality parameters. Overall, both DII and E-DII displayed significant negative correlations with sperm motility and count (p<0.001), suggesting that greater dietary inflammation is linked to poorer sperm quality. However, the correlation with sperm morphology was not statistically significant. More specifically, the mean DII was 1.23±1.1, while the mean E-DII was 0.49±0.43. Semen analysis indicated that the mean sperm motility, morphology, and count were 43.08%±19.30%, 78.03%±26.99%, and 48.12±44.41 million, respectively (Table 2). Pearson correlation analysis was performed to explore the relationships between DII and sperm parameters. The results demonstrated significant inverse correlations between DII and both motility (r=−0.353, p<0.001) (Figure 1) and count (r=−0.348, p<0.001) (Figure 2), as indicated in Table 3. However, DII did not show a significant correlation with sperm morphology (r=−0.108, p=0.240). Pearson correlation tests were also used to examine the associations between E-DII and semen parameters. The findings revealed significant inverse correlations between E-DII and both motility (r=−0.389, p<0.001) (Figure 3) and count (r=−0.372, p<0.001) (Figure 4), as shown in Table 4. However, the correlation between E-DII and sperm morphology (r=−0.123, p=0.177) was not significant. Multivariate analysis, adjusting for age and BMI, was used to further assess the relationship between E-DII and sperm parameters (Table 5). As shown in Table 5, after adjusting for age and BMI, both sperm motility (p=0.001) and sperm count (p=0.002) were inversely correlated with E-DII. However, sperm morphology and E-DII did not display a significant correlation (p=0.306).

Discussion
In a hospital-based cross-sectional study, including 144 men at the referral infertility clinic of Kosar Hospital between 2022 and 2023, we observed inverse correlations of sperm motility and count with DII and E-DII. In this study, age and BMI were the most influential founders of the relationships between DII and sperm parameters. Therefore, we conducted a multivariate analysis, controlling for age and BMI. All participants in this study were healthy and had no chronic disorders, including hyperglycemia, hyperlipidemia, hypertension, or others, over at least the prior 6 months; furthermore, they were not taking any medication. These criteria increased the power of the study.

Two recently developed instruments, the DII and the E-DII, are used to evaluate the inflammatory potential of a diet. These instruments are applicable to any population for which suitable dietary information is available. Higher DII scores have been linked to a heightened susceptibility to cancer [24] and cardiovascular disease [24]. Moreover, a prospective association has been observed between higher levels of biochemical indicators of chronic inflammation, namely CRP, and a greater risk of infertility [25,26]. To date, multiple epidemiological studies have examined the links between DII and long-term diseases such as cancer [27,28], metabolic syndrome [29], and cardiovascular disease [30,31]. The results of this study support the concept that elevated DII levels negatively impact health.

Remarkably, prior to this research, the investigation of the association between DII and the risk of male infertility was limited to a single cross-sectional study of 144 healthy male college students. The findings of that study revealed notable positive correlations between
Table 1. Dietary intake of participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy</td>
<td>2,032.52</td>
<td>4,042.84</td>
<td>2,673.5507</td>
<td>410.02080</td>
</tr>
<tr>
<td>Total protein</td>
<td>60.64</td>
<td>134.04</td>
<td>82.0968</td>
<td>12.70432</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>229.23</td>
<td>599.05</td>
<td>367.6256</td>
<td>67.29350</td>
</tr>
<tr>
<td>Total fat</td>
<td>69.62</td>
<td>205.12</td>
<td>108.0548</td>
<td>24.49903</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>257.58</td>
<td>1218.87</td>
<td>448.8992</td>
<td>128.20191</td>
</tr>
<tr>
<td>Total saturated fat</td>
<td>25.52</td>
<td>124.02</td>
<td>48.7234</td>
<td>18.00274</td>
</tr>
<tr>
<td>Total monounsaturated fatty acids</td>
<td>20.32</td>
<td>59.96</td>
<td>29.7738</td>
<td>5.85612</td>
</tr>
<tr>
<td>Total polyunsaturated fatty acids</td>
<td>9.51</td>
<td>28.98</td>
<td>15.6736</td>
<td>3.27120</td>
</tr>
<tr>
<td>Total linoleic</td>
<td>19.11</td>
<td>59.58</td>
<td>31.1599</td>
<td>7.07349</td>
</tr>
<tr>
<td>Linolenic eicosapentaenoic acid docosahexaenoic acid g</td>
<td>0.06</td>
<td>2.51</td>
<td>0.6629</td>
<td>0.39014</td>
</tr>
</tbody>
</table>

DII and both total sperm motility and progressive sperm motility within this group [20]. However, these results may be subject to limitations due to the small sample size and the narrow age range of participants (20 to 40 years old). The results of our study also suggested an inverse correlation between DII and sperm motility. Separately, the dietary habits of patients with normospermia and oligoasthenoteratozoospermia who sought treatment at an infertility clinic were examined. The findings indicated that individuals who consumed foods high in fat, such as whole dairy products and meats, and had a low intake of specific micronutrients like folate, vitamin C, and lycopene, exhibited poorer seminal quality [32]. The adoption of a “prudent” dietary pattern, characterized by a substantial consumption of fish, chicken, fruit, vegetables, legumes, and whole grains, has demonstrated a significant correlation with higher sperm motility in young men [33] and improved sperm concentration in men seeking treatment at an infertility clinic [34]. However, among men utilizing reproductive treatments, a favorable correlation has also been found between sperm concentration and adherence to a traditional Dutch diet. This diet is characterized by a high consumption of meat, pota-

Table 2. Mean semen analysis factors and dietary inflammatory indices

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DII</td>
<td>−1.71</td>
<td>4.75</td>
<td>1.23</td>
<td>1.10</td>
</tr>
<tr>
<td>E-DII</td>
<td>−0.48</td>
<td>1.96</td>
<td>0.49</td>
<td>0.43</td>
</tr>
<tr>
<td>Motility (%)</td>
<td>0.61</td>
<td>100</td>
<td>43.08</td>
<td>19.30</td>
</tr>
<tr>
<td>Morphology (%)</td>
<td>10.00</td>
<td>100</td>
<td>78.03</td>
<td>26.99</td>
</tr>
<tr>
<td>Count (million)</td>
<td>0.20</td>
<td>200</td>
<td>48.12</td>
<td>44.41</td>
</tr>
</tbody>
</table>

SD, standard deviation; DII, dietary inflammatory index; E-DII, energy-adjusted dietary inflammatory index.
Table 3. Correlations between DII and sperm parameters

<table>
<thead>
<tr>
<th></th>
<th>Motility (%)</th>
<th>Morphology (%)</th>
<th>Count (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>−0.353</td>
<td>−0.108</td>
<td>−0.348</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt; 0.001</td>
<td>0.240</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

DII, dietary inflammatory index.

Table 4. Correlations between E-DII and sperm parameters

<table>
<thead>
<tr>
<th></th>
<th>Motility (%)</th>
<th>Morphology (%)</th>
<th>Count (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>−0.389</td>
<td>−0.123</td>
<td>−0.372</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt; 0.001</td>
<td>0.177</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

E-DII, energy-adjusted dietary inflammatory index.

Table 5. Prediction of E-DII value by sperm parameter after adjusting for age and body mass index

<table>
<thead>
<tr>
<th>Relation between E-DII and sperm parameters</th>
<th>Unstandardized coefficient</th>
<th>Beta coefficient</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motility (%)</td>
<td>−0.006</td>
<td>−0.306</td>
<td>−3.451</td>
<td>0.001</td>
</tr>
<tr>
<td>Morphology (%)</td>
<td>−0.001</td>
<td>−0.092</td>
<td>−1.029</td>
<td>0.306</td>
</tr>
<tr>
<td>Count (million)</td>
<td>−0.003</td>
<td>−0.0276</td>
<td>−3.179</td>
<td>0.002</td>
</tr>
</tbody>
</table>

E-DII, energy-adjusted dietary inflammatory index; SE, standard error.

toes, and whole grains, as well as a low consumption of beverages and sweets.

A recent study indicated that among young men, a Western diet heavy in processed meats, fried potatoes, and snacks was linked to a higher percentage of sperm of normal morphology [35]. Separate research conducted by Liu et al. [11] in Liaoning, China, examined dietary habits that may resemble pro-inflammatory diets commonly observed in Western dietary patterns. Furthermore, two prior studies have examined the correlation between dietary habits and astheno-
zoospermia. Eslamian et al. [36,37] conducted two case-control studies involving a cohort of 107 men with asthenozoospermia and 235 age-matched controls. The objective of these investigations was to explore the potential correlations between dietary and nutritional patterns and the likelihood of developing asthenozoospermia [36,37]. The results indicated a positive correlation between the Western pro-inflammatory dietary pattern and asthenozoospermia, while a pattern characterized by predominantly antioxidant nutrients with anti-inflammatory properties may be inversely associated with asthenozoospermia. A previous investigation demonstrated a potential correlation between inflammation and its impact on prostate function, which then influences sperm quality [38]. Evidence indicates that infections in the reproductive tract and higher levels of inflammatory factors can harm male reproduction, particularly spermatogenesis and semen quality; however, the biological processes underlying this link between these factors and disorders like DII and asthenozoospermia are still not fully understood [39]. Consequently, further investigation is necessary to better comprehend this relationship.

A notable benefit of this study was its utilization of a validated FFQ as a robust tool for gathering information regarding individuals’ habitual food consumption patterns, particularly in relation to inflammatory characteristics. Furthermore, the DII was employed as a research instrument to examine the impact of the whole dietary pattern on semen parameters rather than isolating specific meals or nutrients. The findings of our study align with previous research, suggesting that semen quality may be influenced by an inflammatory milieu characterized by factors such as reactive oxygen species, interleukins, and TNF [40]. Accordingly, previous research has demonstrated significant correlations between DII and most of the sperm parameters that we investigated. Nevertheless, our findings support a definitive inference regarding the observed correlations of DII and E-DII with sperm motility.

Previous research has primarily examined the impact of individual food ingredients or food groups on semen quality. In comparison, few studies have used dietary patterns to investigate the correlations between diet and sperm parameters [41]. Thus, our study has several strengths. It is among the limited research focused on the relationships between DII/E-DII and sperm quality. The use of these well-established indices (DII and E-DII) to assess dietary inflammation provides a comprehensive measure of dietary inflammatory potential. Additionally, adjusting for potential confounders such as age and BMI strengthens the validity of our findings. However, like all studies, the present research also had limitations. The cross-sectional nature of the study limits the ability to establish causality and the direction of the observed associations. Furthermore, the sample only included men attending an in vitro fertilization clinic, which may not represent the general population. The findings relied on self-reported dietary intake, which may be subject to recall bias. Finally, larger multicenter longitudinal population studies may be warranted to improve the statistical power, while clarifying the temporal associations between dietary factors and semen quality. Additional research is required to overcome these limitations, to gain deeper insight into the potential impact of dietary interventions on male fertility outcomes, and to comprehend the fundamental mechanisms behind the observed correlations.

In conclusion, the study results reveal significant negative correlations between dietary inflammatory indices (DII and E-DII) and sperm quality parameters, specifically motility and count. This indicates that diets with a lower inflammatory potential may improve sperm quality. Modifying dietary patterns to decrease inflammation could be a promising approach to improving reproductive health. Future research should explore the long-term effects of dietary modifications on sperm quality and broader reproductive outcomes. In conclusion, our findings suggest that a diet with greater anti-inflammatory characteristics may be associated with better sperm motility and count, although it did not significant impact sperm morphology. However, further research is necessary to validate these findings and generalize the outcomes to diverse cohorts of male participants.

**Conflict of interest**

No potential conflict of interest relevant to this article was reported.

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Investigation: SD, SBA, JR, RV, HGB.
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Writing-review & editing: SS, FMS, SD, SBA, TBL, MP, JR, RV, HGB.
Approval of final manuscript: SS, FMS, SD, SBA, TBL, MP, JR, RV, HGB.

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