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Impact of Season Variation on Semen Quality: A Comprehensive Retrospective Analysis of Data From Patients at an Eastern Iranian Tertiary Care Fertility Center Over a Decade

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Abstract

Seasonal changes are assumed to affect various sperm characteristics based on photoperiods, temperature, and air pollution. According to the literature, most studies were performed on populations of Western countries, and there are limited studies performed in the Middle East with variable results. This study evaluated the seasonality of sperm characteristics among men of reproductive age in an andrology center in Kerman, Iran, where the seasonal temperature varies significantly, with average temperatures ranging from 50 °F (10 °C) to 75.2 °F (24 °C). We retrospectively evaluated the sperm analysis test record. Sperm samples were obtained from 2,948 men during 10 years, excluding those with azoospermia. Samples were assessed for volume, concentration, motility, and morphology according to the World Health Organization (WHO) criteria. We performed a comprehensive comparative literature review of the studies investigating the association between seasonal variation and sperm quality. The mean semen volume was higher in the summer compared with other seasons ($p = .04$). The mean percentage of sperm motility was higher in the spring and less in winter ($p = .03$). Sperm morphology-related parameters, measured by the percent of normal morphology, were significantly better in winter ($p = .03$). Our findings suggest seasonality of sperm characteristics among men of fertility age. Semen volume, motility, and morphology were affected by the photoperiod of reproductive seasons. Results might support the influential role of seasonal variations in the possibility of fertility, especially among those using assisted reproductive technologies and those with oligospermia.

Keywords

seasonal variations, fertility, sperm analysis, sperm quality

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Introduction

Male infertility is a globally significant issue, proposing harmful effects on societies and individuals. According to the literature, up to 2019, more than 56 million men had infertility with statistical dominancy of sub-Saharan Africa and east of Asia and Europe (Huang et al., 2023). The infertility rate has increased annually from 1990 to 2017 in both genders, with a male infertility rate of 0.291% per year, culminating in a 48% to 58% male proportion in overall rates for infertility etiologies (Starc et al., 2019; Sun et al., 2019). Male infertility is mainly diagnosed with impaired semen quality. Findings from various investigations and a recently published meta-analysis in 2023 have reported a gradual decrease in semen quality over recent years, mainly affecting sperm concentration and morphology, experiencing a more severe decline since 2000 (Levine et al., 2023; Li et al., 2016; Luo et al., 2023; Rolland et al., 2013).

Several factors have been introduced as variables affecting sperm quality, including socioeconomy (Rabinowitz et al., 2022), geography (Auger et al., 2022), hormones (W. Zhao et al., 2020), nutrition (Ferramosca & Zara, 2022), and pollutants (Pizzol et al., 2021). Seasonal variation is among the critical factors associated with sperm quality. Circannual variations of seasons can induce sperm quality fluctuations by affecting photoperiods, temperature, and seasonal air pollution (Santi et al., 2018), proposing a plausible justification for seasonal birth rate differences (Levitas et al., 2013).

Although some studies investigated the role of seasonal variations in semen quality, there are limited studies in Middle Eastern countries. Auger concluded the substantial role of geographical status in semen quality (Auger et al., 2022). We aimed to evaluate the association of seasonal variations with semen quality among men referred to our tertiary center in Kerman, Iran.

Materials and Methods

In this retrospective study, we analyzed the large data series of 10 years of spermograms of all patients referred to our referral infertility center in Afzalipour Hospital, Kerman, Iran. Semen samples were obtained into a sterile container by masturbation following a mean abstinence period of 3 to 10 days, maintained at 37 °C for 15 min. The examination was conducted using a phase-contrast microscope. Each sample was meticulously placed on a prewarmed glass slide and observed under the microscope at 37 °C to ensure accuracy. The sperms were applied onto glass slides, left to dry in the air, and subsequently stained with Papanicolaou dye for morphology assessment. Two observers carefully evaluated the samples using a bright-field microscope with a magnification of 1,000 according to Kruger et al. (1988) criteria.

Further evaluations were carried out until the deviation was reduced to below 10% in cases where the difference between the measures exceeded 10% of normal or abnormal forms. Average values were computed when the deviation was less than 10%. The percentage of morphologically normal sperm was utilized for additional analyses. It is important to emphasize that all observers involved in the microscopic evaluation of sperm morphology received training from the same skilled researcher. The researcher periodically verified the accuracy of the morphological analysis through random slide checks, and any discrepancies were corrected through reanalysis. Semen analysis is categorized according to the World Health Organization (WHO) reference values (Cooper et al., 2010). Each report of spermograms was inclusive of semen volume, sperm concentration, total sperm count, total motility, morphology, and percentage of fast and slow motile sperms. The inclusion criteria for this study encompassed the following factors: being scheduled for routine semen analysis for evaluation of infertile couples at our center, not having undergone a vasectomy, and not currently receiving hormone therapy. Cases with azoospermia were removed from the analysis. We performed a literature review regarding articles published after 2000, evaluating and comparing results of sperm analysis tests according to the season (Table 1).

The study adhered to ethical guidelines outlined in the Declaration of Helsinki, and approval from the institutional review board (Research Ethics Committees of Kerman University of Medical Sciences) was obtained with this code IR.KMU.AH.REC.1396.1696.

To analyze the data, the samples were divided into different seasons based on their collection time. Continuous variables were assessed using the analysis of variance (ANOVA) test, and if their distribution was not expected, a log transformation was applied. However, categorical variables were evaluated using the two tests. The statistical analyses were conducted using the software program Statistical Package for the Social Sciences (version 22.0; SPSS Inc., Chicago, IL). A significance level of $p < .05$ was considered to indicate statistical significance.

Results

Total samples obtained were 2,948 spermograms collected along a 10-year period. First, 189 cases with

Table 1. Literature Review of the Association Between Seasonal Variation and Sperm Quality Among Published Studies After 2000

Author	Year	Country	Season			
			Spring	Summer	Fall	Winter
Current study	2024	Iran	↑ Total motility, fast motile	↑ Volume		↓ Total motility, ↑ normal morphology
Malathi et al. (2023)	2023	India			↑ Slow motile	
Balhara et al. (2022)	2022	India	↓ Normal morphology		↑ Concentration, slow motile, total motility, normal morphology	↓ Concentration, slow motile
Tang et al. (2022)	2022	China	↑ Concentration ↓ Progressive motile	↑ Progressive motile		
AL-Murshdi et al. (2021)	2021	Iraq	↑ Total motility	↓ Concentration, volume, total motility, normal morphology		↑ Volume, concentration, normal morphology
Kabukçu et al. (2020)	2020	Turkey		↓ Concentration	↓ Progressive motile, concentration, count	
Nazem et al. (2018)	2018	USA	↑ Total motility, concentration,		↑ Normal morphology	
Cheng et al. (2019)	2019	USA	↑ Concentration, total motility, count			↑ Concentration, total motility, count
Xie et al. (2018)	2018	Switzerland	↑ Concentration, count, progressive motility	↓ Concentration, count ↑ Normal morphology		
Santi et al. (2018)	2018	Italy		↓ Concentration, count	↓ Concentration, count	
Ozelci et al. (2016)	2016	Turkey	↓ Slow motile ↑ Fast motile, normal morphology		↑ Total motility, slow motile ↓ Fast motile	
De Giorgi et al. (2015)	2015	Italy	↑ pH	↑ Total motility, progressive motility ↓ Count		↑ Count ↓ Total motility, progressive motility
X. Z. Zhang et al. (2013)	2013	China		↓ Count, concentration, volume, motility		↑ Count, concentration, volume, motility
Levitas et al. (2013)	2013	Israel		↑ Slow motile, total motility ↓ Fast motile	↑ Total motility	↑ Concentration, morphology, fast motile ↓ Total motility
Gao et al. (2007)	2007	Canada (Chinese men)	↑ Progressive motile		↓ Concentration, count, total motility, normal morphology	↑ Concentration, count, total motility, normal morphology
Carlsen et al. (2004)	2004	Denmark				
Chen et al. (2004)	2004	USA	↑ Concentration, total motility, normal morphology			
Yogev et al. (2004)	2004	Israel		↓ Count	↓ Concentration	↑ Count, concentration
Chen et al. (2003)	2003	USA				↑ Concentration, count, normal morphology
Krause and Krause (2002)	2002	Germany	↑ Acrosin activity			↑ Count
Henkel et al. (2001)	2001	Germany	↑ Count			
Andolz et al. (2001)	2001	Spain	↑ Count, motility			

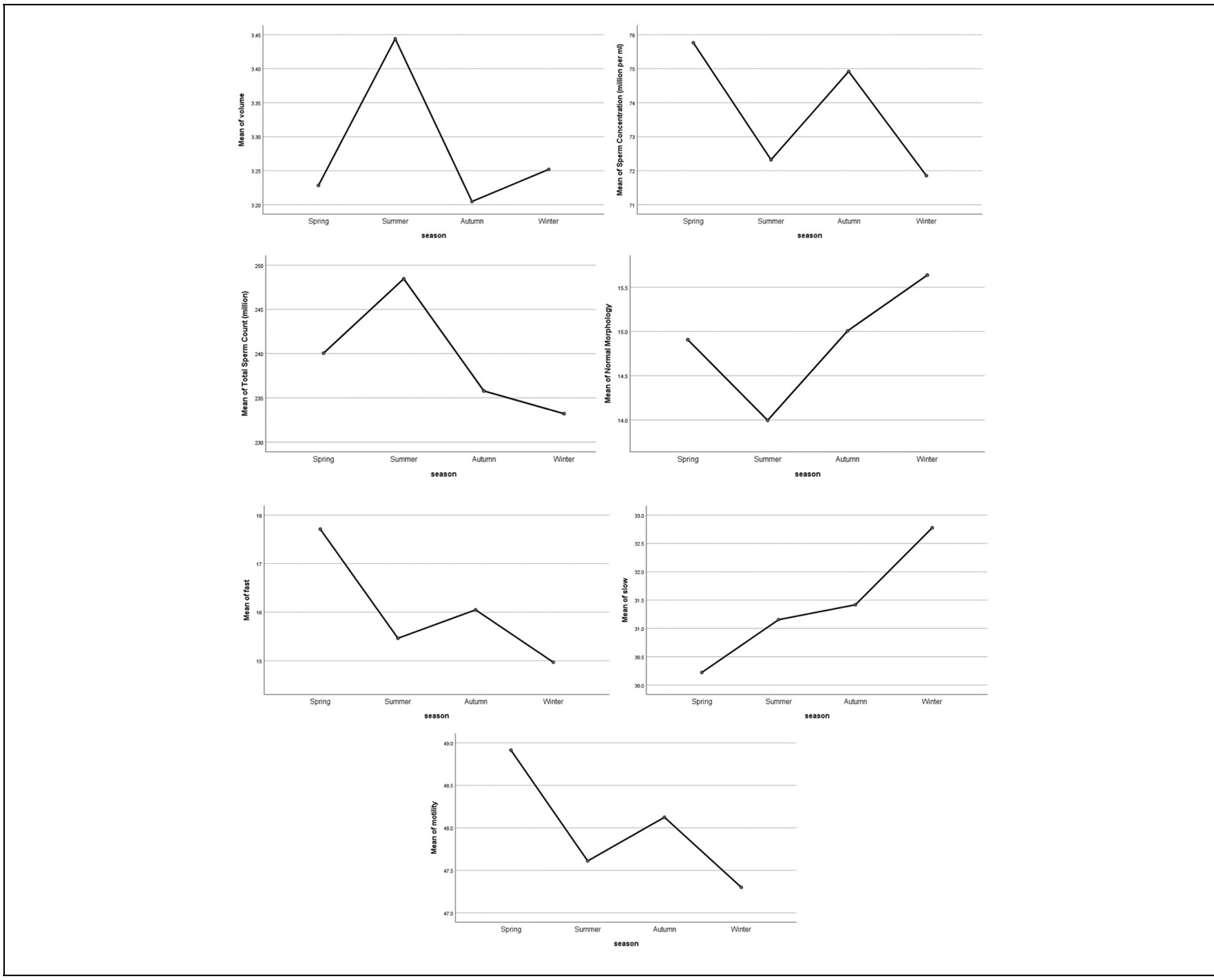

Figure 1. Mean Sperm Parameters Split by Season
Note. The figure illustrates the average sperm concentration over a year, revealing a noteworthy variation between months in volume and morphology (*n* = 2,759). The graph displays the average total progressively fast motile sperm count throughout the year, indicating a significant disparity between months (*n* = 2,759).

azoospermia were excluded. Our findings from 2,759 spermograms revealed that during the summer season, the average volume of semen was higher than that in the other seasons ($p = .04$). In addition, the percentage of fast sperm motility was higher in the spring and lower in winter ($p = .03$). A progressive and steady increase in the mean of normal morphology was observed from summer to winter. When evaluating the sperm morphology parameter based on the percentage of normal morphology, it was observed that samples collected in winter exhibited significantly better results ($p = .03$). Sperm concentration ($p = .18$) and total sperm count ($p = .40$) did not exhibit the seasonal effect (Table 1). From spring to winter, a gradual and consistent increase in the rate of sperms with slow motility was observed. The comparison of total sperm motility between seasons revealed no significant variation ($p = .47$). However, a significantly higher proportion of sperm displaying fast motility was observed during the spring season ($p = .03$). Gradual changes in semen analysis parameters regarding seasonal variations are summarized in Figure 1.

Discussion

Seasonal variation is well known as an essential factor affecting breeding patterns in mammals (Clauss et al., 2021). The effect of seasonal rotation on sperm quality in humans is still controversial (Levitas et al., 2013; Santi et al., 2018). Investigation of seasonal sperm quality fluctuation might be of great importance, while finding an optimal time frame may increase the probability of a successful conception, especially being helpful in couples with male-related infertility. Because the diversity of geographical areas provides differences in photoperiods, temperature, and seasonal air pollution, concluding an overall pattern for seasonal semen quality changes may not be permissible. In addition, considering that Auger et al. have reported that even sperm quality was different between men in different cities of the same country (Auger et al., 2022), and considering that there is currently lack of evidence on exploring the effect of seasonal changes in the Middle East and especially in Iran, we decided to investigate the seasonal sperm quality changes in men referred to our center in Kerman, Iran, and to perform a comprehensive literature review of the articles that investigated the effect of seasonality on sperm quality (Table 1).

Lemitas et al. studied 6,447 couples investigating the seasonal sperm quality variation, indicating an optimal quality of semen parameters during the winter and spring seasons. They evaluated the number of deliveries in each season, comparing the results with their findings of seasonal sperm patterns, which reported an increased number of deliveries in the fall. Hence, they justified the plausible explanation of peak seasonal deliveries during fall (Levitas et al., 2013). Seasonal rotations may cause such sperm quality fluctuations through different mechanisms. First, the difference in the photoperiods might effectively induce human endogenous patterns. Circannual patterns of photoperiods stimulate the release of melatonin. A meta-analysis published in 2023 by Ebrahimi et al. reported that melatonin was a protective agent against gonadal tissue damage, improving the morphology, count, and motility of rodent sperms.

Moreover, they showed significant enhancement of luteinizing hormone (LH), follicle-stimulating hormone (FSH), and testosterone blood amounts among those treated with >210 mg/kg of melatonin (Dehdari Ebrahimi et al., 2023). Besides, Ortiz et al. reported an improvement in the semen quality of samples obtained from infertile men, especially among those who were candidates for assisted reproductive technologies (Ortiz et al., 2011). Boeri et al. also supported the influential role of melatonin in semen quality, introducing melatonin as an antioxidant agent providing proliferation of sperm cells via regulation of immune and hormonal systems (Lucignani et al., 2022). Mohammed H. Hassan et al. compared seminal and blood amounts of melatonin among fertile and infertile men, indicating a significantly lower amount of melatonin among infertile men. Furthermore, they divided the men, exposing some to night-light and evaluated the seminal and blood amounts of melatonin and sperm motility, culminating in a decreased amount of melatonin and sperm motility among those with night-light exposure in both fertile and infertile men, supporting the crucial role of photoperiods in melatonin secretion patterns and their subsequent effect on sperm quality (Hassan et al., 2020). This study was performed in Kerman, Iran. Kerman is a city with four seasons in the south-central district of Iran with almost 1,755 m above the sea level, located at 30.29 north latitude and 57.06 east longitude—photoperiods in Kerman change from almost 14:06′ on June 21 to almost 10:12′ on December 21. July has the longest photoperiods of 388 hr and January has the lowest sunshine periods of 194 hr. Our results supported the previous findings, indicating the most optimal morphology of sperms during the winter season with mean photoperiods of 11:09′.

Second, seasonal temperature variation is another known factor affecting sperm quality because spermatogenesis is mainly sensitive to ambient temperature. Ambient temperature is also indicated to be related to stillbirth, preterm labor, and birth weights (Ha et al., 2017). Hamerezaee et al. advocated a substantial role of ambient temperature in the sperm quality of workers exposed to heat stress, significantly decreasing the quality of obtained semen samples (Hamerezaee et al., 2018). Kabukçu et al. evaluated 6,116 semen samples, investigating the role of seasonal variation in changes in humidity, photoperiods, and ambient temperature on sperm quality fluctuations, and concluded that ambient temperature is detrimental to sperm quality (Kabukçu et al., 2020). Kerman is surrounded by mountains on the high margin of the Lut Desert. Our patients experienced an annual average temperature of 16.48 °C (61.7 °F) ranging from 50 °F (10 °C) to 75.2 °F (24 °C). According to a large longitudinal study conducted in China for 5 years on 10,802 men, the ambient temperature of 13 °C was introduced as the optimal temperature, indicating a 4.09×10^6 and 5.87×10^6 decrease in sperm count for each 5 °C temperature decrease and increase, respectively. They advocated a U-shaped association between sperm quality and ambient temperature, indicating the destructive inverse effect of high and low temperatures on semen quality (Zhou et al., 2020). In concordance with the findings mentioned above, we found lower sperm motility during winters with an average high temperature of 14.9 °C (58.8 °F) and an average low temperature of −3.1 °C (26.4 °F). We showed optimal sperm motility during the spring season with an average temperature range of 11.4 °C (52.5 °F) (March) to 25.6 °C (78.1 °F) (June). Third, season-related air pollution is another influential factor affecting sperm quality (Santi et al., 2018; J. Zhang et al., 2020). A meta-analysis published in 2020 including 4,562 men evaluated the role of air pollution in semen quality and supported the destructive role of air pollution in decreasing semen quality (J. Zhang et al., 2020). Wang et al. depicted substantial adverse effects of gaseous pollutants, including sulfur dioxide and nitrogen dioxide, on semen quality (Wang et al., 2020). Two studies investigated the semen quality of motor tollgate workers, advocating the destructive effects of pollutants released from automobile exhaust (Calogero et al., 2011; Wdowiak et al., 2019). In a large cohort of 33,876 men, exposure to air pollutants of $\leqslant 10$ μm in size was significantly introduced as destructive agents, decreasing semen motility (Y. Zhao et al., 2022). Finally, a review article published in 2018 reported that despite the lack of consensus between the findings of different studies investigating air pollution's effect on semen quality, the overall conclusion advocated the adverse effects of pollutants on semen analysis variables (Jurewicz et al., 2018). In 2019, Kerman recorded a PM2.5 reading of 12.1 to 35.4 $\mu g/m^3$, placing it within the category of moderate pollution. Throughout the year, Kerman consistently experienced similar moderate pollution levels. In April, the pollution levels peaked at 26.3 $\mu g/m^3$. With a PM2.5 reading of 15 $\mu g/m^3$, September was the cleanest month observed. In Kerman, the patients were from the same region and were more homogeneous than those in larger cities, including Tehran, which can be encountered as the study's strength.

The current investigation has limitations and strengths. It is retrospective and lacks data on hormonal analysis or climatic measures, limiting the exploration of potential correlations. In addition, considering that the sperm life cycle is 64 days on average (Durairajanayagam et al., 2015), the observed changes may have occurred due to the 64-day changes from production to ejaculation. Another potential limitation of our study is the lack of investigation into the impact of holidays and vacation times on sperm quality. In Iran, certain holidays like Nowruz in spring and Ramadan that change with the lunar calendar are culturally and socially significant. These events often involve changes in lifestyle, dietary habits, and stress levels, which could potentially influence sperm quality. This aspect represents an interesting area for future research. While a definitive conclusion cannot be reached, this study supports the hypothesis of a positive association between semen parameters and seasons. Further research is needed to understand the mechanisms behind these relationships.

Conclusion

In this study, we observed that the patient had optimal sperm motility during spring, and sperm morphology was optimally observed during winter. This concorded with the seasonal effects of photoperiod, temperature, and air pollution.

Declaration of Conflicting Interests

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Availability of Data and Materials

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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