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Original article

The Impact of Sociodemographic Factors, Lifestyle, and Medical History on Semen Quality in Young Men

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Abstract: *Background* — The trend of declining male fertility worldwide has been a constant concern for the past several decades. Male infertility accounts for half of all infertility cases globally. Unfortunately, information regarding semen quality is inaccurate and contradictory. Therefore, the aim of this study is to investigate the impact of sociodemographic factors, lifestyle, and medical history on semen quality in young men in western Iran.
Methods — The study included 200 men under 40 years of age who underwent semen analysis at an andrology laboratory from October 2022 to August 2023. Along with results of semen analysis, demographic, clinical, and lifestyle data were collected, including BMI, smoking frequency per week, physical activity, income, place of residence, age, comorbidities, and education of the participants. Researchers used descriptive continuous variables, which were presented as mean and standard deviation; qualitative variables were presented as frequency (%). The Kolmogorov-Smirnov test, Q-Q plot, and histogram were used to check the normality of the distribution. Correlation analysis was employed to study the correlation between the studied variables and semen quality. Data were analyzed by SPSS 20 software.
Results — The mean age of the participants (±standard deviation) was 34.9±5.9 years (range: 23-52 years). Most participants were non-smokers (66.0%), urban residents (73.5%), had normal weight (46.97%), primary education (73.74%), low physical activity (72.5%), and low income (48.24%). The mean and 95% confidence interval for sperm count (in millions), concentration (in millions), morphology, and motility were 114.61 (104.28-125.184), 37.76 (35.13-40.36), 0.057 (0.052-0.062), and 0.47 (0.45-0.49), respectively. The results of this study show that various factors, such as age, physical activity, income, and smoking status, significantly affect sperm quality and quantity.
Conclusion — This study emphasizes the importance of sociodemographic factors, lifestyle, occupational hazards, and medical history influencing male fertility. Therefore, to improve reproductive health, it is necessary to identify and promptly eliminate risk factors.

Keywords: Male infertility, sperm parameters, age, lifestyle, clinical conditions.

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Introduction

Infertility remains a significant global public health problem and an important clinical issue affecting 15% of couples of reproductive ages [1]. The incidence of male infertility is quite high [2]. Infertility related to the so-called *male factor* is defined as an alteration in sperm concentration, motility, and morphology in at least one of two semen analyses taken 1 to 4 weeks apart [3-4]. In humans, infertility is the cause in 40-50% of cases and affects approximately 7% of men. Male infertility sometimes arises from abnormalities in sperm, and sperm quality is used as an indirect indicator of male fertility [5-7]. In recent decades, numerous researchers have shown a global decline in human sperm quality [8]. Numerous factors, both hereditary and environmental, can influence infertility rates [9]. Male factors contribute to infertility in 50% of couples worldwide [10]. Approximately 30-50% of cases of male infertility are classified as idiopathic [11]. Various idiopathic factors, including smoking, alcohol consumption, drug use, obesity, psychological stress, older age, nutritional factors, exposure to environmental or occupational toxins, diet, physical activity, carrying a mobile phone in a trouser pocket, and sleep duration, have been identified as potential risk factors for reduced semen quality [12-15]. The latter decreases the likelihood of egg fertilization, thereby affecting the success of conception [16]. Untreated male infertility increases the likelihood of further systemic consequences such as cardiovascular, urogenital, and metabolic diseases, as well as cancer. These conditions collectively affect the quality of life of those affected [17]. Regarding male age and fertility, some data link decreased fertility potential to older age, which is supported by the results of assisted reproductive technologies [18-20].

Nevertheless, further consensus is needed regarding the impact of male aging on sperm quality. While some studies have shown a correlation between male aging and sperm quality, other

studies have not found such a link [21-24]. Several studies have investigated the impact of certain clinical and lifestyle factors, including obesity, alcohol consumption, and smoking, on sperm parameters. The prevalence of obesity is a growing public health concern. The American Medical Association recently defined obesity as a disease [25]. While the main focus in studying the negative consequences of obesity is on overall health, available data suggest that reproductive health is also affected. Several studies have shown that an increased body mass index (BMI) in men may lead to decreased sperm production [26-27].

Conversely, other studies have not found a correlation between male body mass index (BMI) and sperm characteristics [28-29]. Moreover, the relationship between body size and sperm quality after weight loss further complicates our understanding of this issue. Some studies have shown a decrease in sperm production associated with significant weight loss, while others have observed an improvement in sperm characteristics [27,30-31]. However, both alcohol consumption and smoking are thought to have detrimental effects on male fertility and, consequently, on reproductive outcome [32]. Nevertheless, the impact of these factors on standard sperm characteristics is still a subject of debate [33-36].

As a matter of fact, a comprehensive study of the impact of excessively high BMI, alcohol consumption, and smoking on the decline in sperm quality with age has not yet been conducted. Furthermore, it is crucial to consider the significant influence of concomitant systemic diseases on infertility and sperm quality. The complexity of identifying the underlying causes of male subfertility and infertility significantly limits treatment and intervention options. The undeniable influence of sociodemographic factors on both the general health of men and their reproductive health is evident [37-41]. The goal of this descriptive cross-sectional study was to investigate the correlation between various demographic and lifestyle characteristics and standard sperm parameters to determine the impact of lifestyle and demographic factors on sperm function. Hence, we aimed at assessing the influence of age, clinical conditions, and lifestyle on semen samples from patients attending an andrology laboratory, in accordance with World Health Organization (WHO) recommendations. The study was conducted under controlled conditions, using the same operators, equipment, and laboratory procedures, adhering to strict quality standards.

Material and methods

Study population

The study initially included men under 40 years of age who underwent semen analysis at the andrology laboratory from October 2022 to August 2023. All participants provided written informed consent. Individuals with pre-existing andrological and systemic diseases known to contribute to poor sperm quality were excluded from the study based on specific criteria in effect at that time. A total of 200 men seeking infertility treatment were included in the study. *Table* 1 presents the main characteristics of the men referred to the Center for Infertility Treatment. The mean age of the participants (±standard deviation) was 34.9±5.9 years (range: 23-52 years). The majority of participants were non-smokers (66.0%), urban residents (73.5%), had a normal weight (46.97%), primary education (73.74%), low physical activity (72.5%), and low income (48.24%).

Table 1. Baseline characteristics of men referred to Urmia University of medical sciences Infertility center

Variables	*Category*	*N (%)*
Age	<30	52 (26%)
	30-40	113 (56.5%)
	>40	35 (17.5%)
Physical Activity	Low	145 (72.5%)
	Moderate	52 (26.0%)
	High	3 (1.5%)
Income	Low	96 (48.24%)
	Moderate	91 (45.73%)
	High	12 (6.03%)
Smoking status	Smoker	68 (34.0%)
	Non-Smoker	132 (66.0%)
Residency	Urban	147 (73.5%)
	Rural	53 (26.5%)
BMI	<24.9	93 (46.97%)
	24.9-30	78 (39.39%)
	>30	27 (13.64%)
Education	Elementary	146 (73.74%)
	Academic	52 (26.26%)
Comorbidity	No	183 (91.5%)
	Diabetes	8 (4.0%)
	Hypertension	1 (0.5%)
	High Closterolemy	5 (2.5%)
	Heart disease	2 (1.0%)
	Respiratory Disease	1 (0.5%)
RBC	Observed	9 (4.5%)
	Non-Observed	191 (95.5%)
WBC	Observed	20 (10.0%)
	Non-Observed	180 (90.0%)
Round Cell	Yes	153 (76.5%)
	No	47 (23.5%)

Exclusion criteria were as follows:

(1) Azoospermia, absence of sperm in the semen;

(2) Andrological conditions that may affect sperm quality, such as genetic disorders affecting the sex chromosome (e.g., AZFc microdeletion), previous mumps with testicular involvement, severe varicocele (unilateral or bilateral), undescended testicles, previous testicular torsion or scrotal trauma, congenital bilateral absence of the vas deferens (CBAVD), and urogenital infections;

(3) Use of medications known to affect sperm quality, including steroids, finasteride, and calcium channel blockers;

(4) History of cancer;

(5) Known mental disorders;

(6) Substance abuse;

(7) Inability to complete the lifestyle questionnaire.

Semen analysis was performed in all participants as part of the standard procedure. For research purposes, additional sperm testing was conducted on a subset of participants with sufficient remaining sperm samples after standard diagnostic evaluation, including sperm viability assessment, androgen receptor (AR) assay, and sperm DNA fragmentation assessment. The study received approval from the Research Ethics Committee (IR.UMSU.REC.1401.261).

Semen analysis

Semen samples were collected at the hospital by masturbation after a period of sexual abstinence for 3-7 days. The semen analysis was performed manually *sensu* the World Health

Organization guidelines (version V) (WHO 2010). After collection, semen samples were liquefied at 37 °C and then evaluated within a maximum of 1 hour after ejaculation. Semen volume was measured after liquefaction using a wide bore graduated pipette with 0.1 mL divisions. Researchers determined sperm concentration and assessed motility using a phase-contrast microscope (OLYMPUS BX43, Japan) at 200× or 400× magnification. Sperm concentration was measured using standard dilutions as needed, and counting was performed after a 10-15-minute sedimentation period using improved Neubauer hemocytometers. For sperm motility assessment, a wet mount was prepared by placing 10 µL of the semen sample on a 22 mm × 22 mm coverslip. Repeated assessments were performed, with at least 200 spermatozoa examined during each assessment. Sperm morphology was assessed using Tygerberg strict criteria. Slides were stained using the Diff-Quik staining kit (Dade Behring AG, Switzerland). Assessments were performed using a microscope with a 100× oil immersion objective (OLYMPUS BX43, Japan). The analyses were performed by a qualified technician blinded to the study.

Demographic and lifestyle factors studied in relation to sperm quality

Demographic and lifestyle data were collected using a self-administered questionnaire before or after the semen collection procedure. The questionnaire covered potential risk factors. Participants were given explanations of the questionnaire items before completing it. In this study, participants were categorized based on certain characteristics. The categorization is presented in *Table* 1, which describes the grouping of variables such as age, physical activity, income, smoking status, place of residence, BMI, and other relevant factors. Regarding physical activity, participants were divided into three groups: low, moderate, and high. However, due to the small number of participants in the high physical activity group (only three individuals), the analysis was limited to two groups: low physical activity and moderate/high physical activity. Similarly, for the BMI variable, individuals with a BMI less than 18.5 (only two participants) were considered to be of normal weight.

Statistical processing of collected data

Continuous variables are presented as mean and standard deviation; qualitative variables are presented as frequency (%). The Kolmogorov-Smirnov test, Q-Q plot, and histogram were used to check for normality of distribution. In case of non-compliance with the assumption of normal distribution, bootstrapping was employed. If no statistically significant differences were observed between the results, tests assuming a normal distribution were subsequently applied. Multiple regression analysis was used to examine the relationship between sperm motility, sperm count (in millions), sperm morphology, and sperm concentration (in millions). The results are presented as a coefficient (β) and the corresponding 95% confidence interval (CI). The model was built using a backward stepwise selection algorithm. All variables with a p-value of less than 0.1 in the univariate analysis were considered as potential candidates for inclusion in the multivariate linear regression model.

Table 2. Crude and adjusted coefficients and 95% confidence intervals (CI) for association between studied variables and sperm motility

Variables	*Crude Coeff (95% CI)*	*P-value*	*Adjusted Coeff (95% CI)*	*P-value*
age (per 10 years)	-7.83 (-10.81, -4.85)	<0.001	-5.39 (-7.93, -2.64)	<0.001
Physical Activity				
Low	1		1	
Moderate or high	14.44 (10.85, 18.03)	<0.001	10.33 (6.73-13.91)	<0.001
Income				
Low	1		1	
Moderate or High	7.12 (3.6-10.65)	<0.001	3.74 (0.58-6.89)	0.02
Smoking status				
Smoker			1	
Non-Smoker	8.29 (4.58-11.99)	0.002	5.01 (1.67-8.33)	0.003
Residency				
Urban	1		1	
Rural	3.76 (1.38-8.46)	0.037	2.41 (-1.01-5.81)	0.17
Adjusted R2			0.343	

Table 3. Crude and adjusted coefficients and 95% confidence intervals (CI) for association between studied variables and sperm count (Million)

Variables	*Crude Coeff (95% CI)*	*P-value*	*Adjusted Coeff (95% CI)*	*P-value*
age (per 10 years)	-43.45 (-60.72 - -26.20)	<0.001	-34.11 (-50.02 - -18.21)	<0.001
Physical Activity				
Low	1		1	
Moderate or high	68.01 (46.24-89.76)	<0.001	42.33 (20.55-64.11)	<0.001
Income				
Low	1		1	
Moderate or High	7.12 (3.6-10.65)	<0.001	39.05 (19.88-58.21)	0.02
Smoking status				
Smoker	1		1	
Non-Smoker	40.42 (18.76-62.08)	<0.001	19.63 (-0.34-39.59)	0.003
BMI	-3.14 (-4.93 - -1.36)	<0.001	-1.71 (-3.32 - -0.11)	0.036
Adjusted R2			0.373	

Table 4. Crude and adjusted coefficients and 95% confidence intervals (CI) for association between studied variables and sperm morphology

Variables	*Crude Coeff (95% CI)*	*P-value*	*Adjusted Coeff (95% CI)*	*P-value*
age (per 10 years)	-1.45 (-2.29 - -0.61)	<0.001	-0.92 (-1.68 - -0.15)	0.018
Physical Activity				
Low	1		1	
Moderate or high	3.51 (2.51-4.52)	<0.001	2.63 (1.59-3.69)	<0.001
Income				
Low	1		1	
Moderate or High	1.75 (0.78-2.72)	<0.001	1.03 (0.12-1.96)	0.027
Smoking status				
Smoker	1		1	
Non-Smoker	1.81 (0.78-2.84)	<0.001	1.03 (0.06-1.99)	0.035
Adjusted R2			0.249	

Table 5. Crude and adjusted coefficients and 95% confidence intervals (CI) for association between studied variables and sperm concentration (Milion)

Variables	*Crude Coeff (95% CI)*	*P-value*	*Adjusted Coeff (95% CI)*	*P-value*
age (per 10 years)	-8.92 (-13.26 - -4.57)	<0.001	-6.04 (-10.18 - -1.91)	<0.001
Physical Activity				
Low	1		1	
Moderate or high	13.86 (8.33-19.41)	<0.001	8.49 (2.92-14.06)	0.003
Smoking status				
Smoker	1		1	
Non-Smoker	10.67 (5.34-15.99)	<0.001	7.64 (2.56-27.23)	0.022
Adjusted R2			0.284	

Results

The mean and 95% confidence interval for sperm count (in millions), concentration (in millions), morphology, and motility were 114.61 (104.28-125.184), 37.76 (35.13-40.36), 0.057 (0.052-0.062), and 0.47 (0.45-0.49), respectively. *Table* 2 shows that with every 10-year increase in age, sperm motility decreases by 5.39%. Furthermore, moderate or high physical activity, compared to low activity, was significantly associated with higher sperm motility (β=10.33; 95% CI: 6.73-13.91). Individuals with moderate or high income had significantly higher sperm motility vs. those with low income (β=3.74; 95% CI: 0.58-6.89). The adjusted R-squared value of 0.343 implies that the model explains approximately 34.3% of the variation in sperm motility. *Table* 3 examines the relationship between various variables and sperm count. With each year of increasing age, sperm count decreases by 3.41 million. Men with high physical activity had a higher sperm count.

In addition, individuals with moderate or high income and non-smokers had a higher sperm count. A higher BMI was also associated with a lower sperm count. Overall, *Table* 4 suggests that younger age, moderate or high physical activity, higher income, and smoking cessation are associated with better sperm morphology in the studied population. *Table* 5 shows that younger age, moderate or high physical activity, and smoking cessation are associated with higher sperm concentration in the studied population. The study showed that increasing age is associated with a decrease in sperm motility, count, morphology, and concentration. Moderate or high physical activity and smoking cessation are associated with improvements in all sperm parameters. Higher income is associated with improved sperm motility, count, and morphology. Increased BMI is associated with a decrease in sperm count, but no statistically significant association was observed with other sperm parameters. Our results show that place of residence (urban or rural area) does not significantly affect sperm parameters. However, minor effects were observed (e.g., a decrease in sperm motility in urban residents), which were not, however, statistically significant.

Discussion

This study aimed to investigate the influence of demographic, clinical, and lifestyle factors on conventional sperm parameters in men undergoing infertility evaluation. We obtained some interesting results. Our findings indicated an inverse correlation between age and sperm parameters, which supported the data by Verón et al. regarding the influence of age on sperm parameters [42]. Our results are similar to those of Stone et al., who discovered adverse associations between age and ejaculate volume, sperm concentration, and progressive motility [23]. Oliveira et al. found an association between age and ejaculate volume, as well as progressive sperm motility [43]. They also revealed a correlation between age and sperm count, which was consistent with the findings of Harris et al. regarding the importance of sperm concentration and noted a decrease in spermatid concentration in the seminiferous tubules with age, leading to a decrease in sperm concentration [44].

Based on our results, sperm count appears to be the parameter most strongly dependent on age. Thus, the decline in endocrine function that occurs with age may explain the observed age-related deterioration [44-45]. Harris et al. found that the most significant changes in sperm quality are oligospermia, asthenozoospermia, and teratospermia. These changes indicate a gradual deterioration of the typical sperm morphology, similar to a decrease of 0.2-0.9% for each year of life [44]. Previous studies have shown that over 20 years, 4-18% of sperm exhibit abnormal morphology [46]. One of the key findings of this study is the significant decrease in sperm parameters with increasing age. This observation is consistent with previous studies indicating that increasing age is associated with a decrease in sperm concentration, motility, and morphology. For example, a study by Jimbo showed that male fertility declines with age due to a combination of factors such as hormonal changes, increased sperm DNA fragmentation, and decreased overall testicular function [47].

These changes may be based on biological mechanisms such as oxidative stress and a decrease in cellular repair mechanisms over time [47]. The results of our study showed that a high body mass index (BMI) significantly reduces the number of sperm, but we observed no statistically significant correlation with other sperm parameters. A recent study examining variables associated with semen quality in couples seeking assistance at a reproductive clinic showed that men with poor semen quality were three times more likely to be obese, compared with men with satisfactory semen quality. In addition, a striking inverse relationship was observed between sperm quality indicators and BMI in men with normal semen quality [48-49]. This study revealed an inverse correlation between overweight/obesity and the total number, normal morphology, and motility of sperm cells in each individual. At a BMI greater than 30 kg/m^2, the concentration, morphology, and number of normally motile spermatozoa in the ejaculate decreased.

Several studies have reported an inverse correlation between sperm concentration/total sperm count and obesity assessed by body mass index (BMI) [26]. Our results support the findings of previous studies [26-30] that demonstrated an inverse correlation between body weight and total sperm count. A previous meta-analysis revealed a J-shaped relationship between BMI categories and the likelihood of oligospermia or azoospermia [27]. However, two recent multicenter studies with large sample sizes exhibited no association between BMI and sperm quality [50-53]. The etiology of the relationship between obesity and sperm production is complex and unclear. It has been shown that overweight and obesity (especially central obesity) affect GnRH-FSH/LH pulsation, which can disrupt the functions of Leydig and Sertoli cells and thus hinder the release of sex hormones and the production of mature sperm [62-63].

According to our study, smokers showed a significant decrease in sperm parameters, compared with non-smokers. Studies on the effect of tobacco consumption on sperm parameters have shown that semen volume, total motility, percentage of morphologically normal spermatozoa, sperm viability, and sperm membrane integrity are significantly reduced in smokers vs. non-smokers [54-55]. Our study also confirmed these findings. Regarding cigarette smoking, our results are consistent with a meta-analysis that showed the harmful effects of smoking on sperm motility [52]. Jong et al. demonstrated that cigarette smoking does not appear to significantly affect sperm parameters such as volume, sperm count, motility, and morphology in the studied population [56].

In contrast to this study, the results of our study demonstrated that smoking reduces all sperm parameters. Cigarette smoking is a modifiable lifestyle aspect that affects sperm quality, but there are discrepancies regarding the specific amount and duration of time

required for this effect. Mostafa et al. identified a direct relationship between the amount and duration of smoking and its effect on sperm characteristics. They observed that people who smoked heavily for a long period of time had poorer sperm function [53].

The results of our study show that men engaging in moderate or intense physical activity had higher mean values of sperm parameters (motility, morphology, count, concentration) vs. men with low levels of physical activity. Furthermore, a statistically significant difference in sperm cell morphology was observed between the two groups. Men who regularly engage in physical activity demonstrate better sperm quality vs. men leading a sedentary lifestyle [57]. Moreover, physical activity can potentially improve both sperm count and motility [58]. Indeed, physical exercise, by increasing testicular antioxidant protection, reducing levels of pro-inflammatory cytokines, and enhancing the process of steroidogenesis, leads to improved spermatogenesis and sperm quality in cases of lifestyle-induced infertility [60].

Semen quality is influenced by various factors, including geographical differences. Our study revealed a correlation between place of residence, particularly urban living, and below-average semen characteristics. This finding is consistent with the results of a previous study by Zhou et al. [59]. However, our study did not find a statistically significant difference in the mean values of sperm parameters. The study showed a significant correlation between the household income level of the participants and abnormal semen parameters. There are few studies investigating the relationship between sperm characteristics and household income. Nevertheless, Janewich et al. documented that men with lower incomes had increased levels of perceived stress, which affected their sperm characteristics [61]. The discrepancy between this study and our findings may be explained by the participants' adherence to a healthy lifestyle and stable income, even in the lowest income group in this study.

The results of our study demonstrated a decrease in sperm parameters in men with pre-existing medical conditions, but statistical significance was not confirmed. Our study expands our understanding of male infertility and its correlation with potential risk factors; however, it has some limitations. Given the nature of the study, we were only able to identify correlations between several factors and semen parameters, but we could not establish a definitive causal relationship. Our results may not be applicable to the general population, as all participants were specifically selected from an andrology clinic, and the study was conducted in a single center. No measurements of hormonal analysis or functional factors such as DNA fragmentation index and sperm oxidative stress were performed. Incorporating such characteristics could improve our understanding of the underlying mechanism.

Conclusion

This study represents a significant step forward in understanding male fertility, examining the combined influence of various factors. By considering age, sociodemographic characteristics, lifestyle, and medical history in combination, we obtained a more accurate and useful picture of male fertility, reflecting the complexities of real-life situations. The results necessitate a paradigm shift from an exclusive focus on individual parameters to a comprehensive consideration of the individual in the context of determining fertility. This enhanced understanding will allow for more precise diagnostic and treatment protocols for male infertility. Further research is needed to delve deeper into these interrelationships, enabling the application of personalized strategies and treatment methods.

Conflict of interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the study reported in this paper.

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Author contributions

Farzad Maleki analyzed the data. Hojat Ghasemnejad-Berengi and Hamidreza Farrokh-Eslamlou wrote the manuscript. Sonia Sadeghpour and Tahereh Behroozi-Lak contributed to the development of the research concept and also prepared and edited the manuscript. Robabeh Bahadori and Farzad Maleki confirm the authenticity of all original data. All authors have read and approved the final version of the manuscript.

Ethical approval and consent to participate

This study was approved by the Ethics Committee of the Urmia University of Medical Sciences under number IR.UMSU.REC.1401.261. We, the authors of this article, also confirm that we did not use artificial intelligence (AI) or AI technologies in the preparation of this manuscript.

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