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Original Research Article

A COMPARATIVE STUDY OF SEMEN PARAMETERS IN URBAN AND RURAL MEN UNDERGOING INFERTILITY TREATMENT AT A TERTIARY CARE CENTRE

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ABSTRACT

Background: Male infertility contributes to nearly 40–50% of infertility cases globally. Environmental, occupational, and lifestyle differences between urban and rural populations may influence semen quality. This study aims to compare semen parameters among urban and rural men undergoing infertility evaluation at fertility centre of our medical college.

Materials and Methods: A study was conducted at a tertiary care centre involving 500 men as part of infertility working for couple. Participants were categorized into urban (n=260) and rural (n=240) groups based on residence. Semen samples were analyzed according to WHO 2021 guidelines. Parameters assessed include volume, pH, sperm concentration, motility, and morphology. Statistical analysis was performed using t-test and chi-square test.

Results: Urban men showed significantly lower mean sperm concentration (42.3 ± 18.5 million/ml) compared to rural men (48.7 ± 20.2 million/ml, $p<0.05$). Progressive motility was reduced in urban men (32.4%) versus rural (38.6%). Higher prevalence of oligoasthenozoospermia was observed in urban men (28.1%) compared to rural men (19.6%). Azoospermia rates were comparable. Lifestyle factors such as smoking and occupational exposure were significantly higher in urban populations.

Conclusion: Urban men demonstrated poorer semen parameters as compared to rural counterparts show abnormal parameters. Environmental pollution, stress, and lifestyle factors are associated for the public health interventions targeting modifiable risk factors.

Keywords: Male infertility, Semen analysis, Urban population, Rural population, Semen Parameter.

INTRODUCTION

Infertility is a significant global health issue affecting approximately 10–15% of couples worldwide, with male factors contributing to nearly 40–50% of cases.[1,2] Over recent decades, increasing attention has been directed toward declining semen quality, particularly in developing and industrialized regions undergoing rapid urbanization. Semen analysis remains the cornerstone in the evaluation of male infertility, providing critical information regarding sperm concentration, motility, morphology, and seminal fluid characteristics as per World Health Organization (WHO) guidelines.[3]

With reduced sperm concentration, impaired motility, and increased sperm DNA fragmentation,[4-6] a large population-based study from China reported a significant decline in semen quality among men exposed to high levels of ambient air pollution, particularly in urban regions.[5]

Environmental toxins act through mechanisms such as oxidative stress, endocrine disruption, and direct testicular toxicity, ultimately impairing spermatogenesis. Oxidative stress, in particular, has been shown to damage sperm membrane integrity and DNA, leading to reduced fertilization potential.[7] Additionally, endocrine-disrupting chemicals commonly found in plastics, pesticides, and

industrial waste may interfere with hormonal regulation of spermatogenesis.[4]

Lifestyle factors associated with urban living further contribute to declining semen quality. Increased stress levels, sedentary behaviour, obesity, smoking, and alcohol consumption are more prevalent in urban populations and have been independently linked to poor semen parameters.[8,9]

In contrast, rural populations are traditionally perceived to have better reproductive health outcomes due to lower exposure to industrial pollutants and relatively active lifestyles. However, this assumption is not universally valid. Rural populations may be exposed to agricultural chemicals such as pesticides and herbicides, which have been shown to adversely affect semen quality.[11] Jurewicz et al. reported that pesticide exposure is associated with decreased sperm concentration and increased abnormal morphology.[11] Additionally, limited access to healthcare, nutritional deficiencies, intake of tobacco and lack of awareness regarding reproductive health may further influence fertility outcomes in rural settings.

India, like many developing countries, is experiencing rapid urban expansion, making it an important setting to study the impact of urbanization on reproductive health. Tertiary care centre's cater to both urban and rural populations, providing a unique opportunity to assess differences in semen parameters within a clinical context. Despite increasing awareness, there remains a lack of well-designed comparative studies evaluating semen quality between these populations in infertility settings.

Understanding the influence of geographic and environmental factors on semen quality is essential for developing targeted preventive strategies and improving reproductive outcomes. Identifying modifiable risk factors such as lifestyle habits, occupational exposures, and environmental pollutants can help guide clinical Counselling and public health interventions.

Therefore, the present study aims to compare semen parameters between urban and rural men attending a tertiary care infertility centre and to explore potential factors contributing to observed differences.

MATERIALS AND METHODS

The present study was conducted as a hospital-based study at a IVF Centre tertiary care Hospital over a period of one year. A total of 500 male partners of infertile couples attending the infertility clinic for evaluation were included based on predefined inclusion and exclusion criteria. Ethical clearance was obtained from the institutional review board, and informed consent was taken from all participants prior to enrolment.

Participants were categorized into urban and rural groups based on their place of residence, as documented in hospital records and confirmed during clinical interview. Demographic details including age, duration of infertility, occupation, and lifestyle factors such as smoking and alcohol consumption were recorded using a structured questionnaire. Previous medical and surgical history relevant to infertility was also documented.

Semen samples were collected following standard WHO guidelines to ensure uniformity and reliability of results. Participants were instructed to maintain a period of sexual abstinence ranging from 2 to 7 days, with most samples collected after 3–5 days of abstinence. Samples were obtained by masturbation into sterile, wide-mouthed, non-toxic containers in a designated private collection room near the laboratory to minimize sample degradation. In cases where collection was done outside the laboratory, samples were transported within one hour while maintaining near body temperature conditions.

All semen samples were allowed to liquefy at room temperature for 30 minutes before analysis. Macroscopic examination included assessment of volume, color, viscosity, and pH. Semen volume was measured using a graduated pipette, and pH was determined using pH indicator strips. These parameters provide are considered important information regarding accessory gland function and are routinely included in semen analysis protocols.

Microscopic examination was performed to evaluate sperm concentration, motility, and morphology. Sperm concentration was determined using a Neubauer hemocytometer after appropriate dilution. Motility assessment was carried out under light microscopy and classified into progressive motility, non-progressive motility, and immotile sperm, as per WHO criteria.

Sperm morphology was evaluated using stained smears prepared withtechniques such as Papanicolaou or Diff-Quik staining in 1940s, as the standard recommendation by the WHO Lab Manual for examination and processing of human Semen.

Morphological assessment was performed under oil immersion microscopy, and at least 200 spermatozoa were evaluated per sample. Strict criteria were applied to classify normal and abnormal forms, as recommended by WHO guidelines. Quality control measures were maintained throughout the study, including calibration of equipment and periodic validation of laboratory procedures.

Based on semen analysis results, participants were categorized into diagnostic groups such as normozoospermia, oligozoospermia, asthenozoospermia, oligoasthenozoospermia, and azoospermia according to WHO reference values. Normozoospermia refers to a condition in which all semen parameters fall within the normal reference limits as defined by the World Health Organization (WHO), including adequate semen volume, sperm concentration (≥15 million/ml), progressive motility (≥32%), total motility (≥40%), and normal morphology (≥4%), indicating normal male fertility potential. Oligozoospermia is characterized by a reduced sperm concentration below 15 million/ml,

reflecting impaired spermatogenesis and reduced fertility capacity. Asthenozoospermia denotes decreased sperm motility, specifically when progressive motility is less than 32% or total motility is less than 40%, thereby limiting the sperm's ability to reach and fertilize the ovum. Oligoasthenozoospermia represents a combination of both low sperm concentration and reduced motility, indicating a more severe compromise in male fertility. Azoospermia is defined as the complete absence of spermatozoa in the ejaculate, even after centrifugation, and may result from either obstructive causes or primary testicular failure.[12] These classifications are widely used in clinical and research settings to standardize reporting of male infertility.

Diagnostic group	Definition
Normozoospermia	all semen parameters fall within the normal reference limits as defined by the World Health Organization (WHO ,2020), including adequate semen volume, sperm concentration (≥15 million/ml), progressive motility (≥32%), total motility (≥40%), and normal morphology (≥4%), indicating normal male fertility potential.
Oligozoospermia	a reduced sperm concentration below 15 million/ml, reflecting impaired spermatogenesis and reduced fertility capacity.
Asthenozoospermia	decreased sperm motility, specifically when progressive motility is less than 32% or total motility is less than 40%, thereby limiting the sperm's ability to reach and fertilize the ovum.
Oligoasthenozoospermia	a combination of both low sperm concentration and reduced motility, indicating a more severe compromise in male fertility.
Azoospermia	the complete absence of spermatozoa in the ejaculate, even after centrifugation, and may result from either obstructive causes or primary testicular failure.

Data were entered into a structured database and analyzed using statistical software. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as percentages. Comparisons between urban and rural groups were performed using Student's t-test for continuous variables and chi-square test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 500 male participants were included in the study, of which 260 (52%) belonged to the urban group and 240 (48%) to the rural group. The mean age of participants in the urban group was 31.8 ± 5.4 years, while that in the rural group was 32.6 ± 6.1 years. The difference in age distribution between the two groups was not statistically significant ($p > 0.05$), indicating comparability of baseline demographic characteristics.

Lifestyle factors showed notable variation between the two groups. The prevalence of smoking was significantly higher among urban participants (42%) compared to rural participants (28%), and alcohol consumption was also more common in the urban group (36% vs 22%). These differences were statistically significant ($p < 0.01$), suggesting a higher burden of lifestyle-related risk factors in urban men.

On evaluation of semen characteristics, the mean semen volume was slightly lower in the urban group (2.4 ± 0.8 ml) compared to the rural group (2.6 ± 0.7 ml); however, this difference was not statistically significant ($p > 0.05$). Similarly, the mean semen pH values were comparable between the two groups, with no significant variation observed.

A statistically significant difference was observed in sperm concentration between the two groups. Urban men had a lower mean sperm concentration (42.3 ± 18.5 million/ml) compared to rural men (48.7 ± 20.2 million/ml), and this difference was found to be significant ($p < 0.05$). This finding suggests a relative decline in spermatogenic function among urban participants.

Sperm motility parameters also differed significantly between the groups. The percentage of progressively motile spermatozoa was lower in the urban group (32.4%) compared to the rural group (38.6%), and this difference was statistically significant ($p < 0.01$). Non-progressive motility and immotile sperm fractions were correspondingly higher in urban men, indicating compromised sperm functional capacity.

Notably, the prevalence of oligoasthenozoospermia was considerably higher among urban men (28.1%) compared to rural men (19.6%), indicating a combined defect in sperm count and motility in urban populations. The proportion of azoospermia was similar in both groups (approximately 5%), suggesting no significant geographic variation in severe spermatogenic failure.

Table 1: Baseline Characteristics

Parameter	Urban (n=260)	Rural (n=240)	p-value
Mean Age (years)	31.8 ± 5.4	32.6 ± 6.1	0.21
Smokers (%)	42%	28%	<0.01
Alcohol use (%)	36%	22%	<0.01

Table 2: Comparison of Semen Parameters

Parameter	Urban	Rural	p-value
Volume (ml)	2.4 ± 0.8	2.6 ± 0.7	0.08
pH	7.5 ± 0.3	7.6 ± 0.2	0.12
Sperm Count (million/ml)	42.3 ± 18.5	48.7 ± 20.2	<0.05
Progressive Motility (%)	32.4	38.6	<0.01

Table 3: Distribution of Semen Abnormalities

Diagnosis	Urban (%)	Rural (%)	p-value
Normozoospermia	38.5	45.8	0.218
Oligozoospermia	14.2	12.1	
Asthenozoospermia	19.6	17.5	
Oligoasthenozoospermia	28.1	19.6	
Azoospermia	5.0	4.5	

DISCUSSION

The present study aimed to compare semen parameters between urban and rural men undergoing infertility evaluation at a tertiary care center. The findings of this study demonstrate that urban men exhibited relatively poorer semen quality, particularly in terms of sperm concentration and motility, compared to their rural counterparts. These observations are consistent with a growing body of evidence suggesting that environmental and lifestyle factors associated with urbanization negatively influence male reproductive health.

In the present study, a higher proportion of normozoospermia was observed in the rural group (45.8%) compared to the urban group (38.5%), indicating relatively better semen quality among rural men. Conversely, abnormal semen parameters were more prevalent in the urban population. Oligozoospermia was slightly higher in urban men (14.2%) compared to rural men (12.1%), while asthenozoospermia was alsocommon in the urban group (19.6%) than in the rural group (17.5%). Notably, oligoasthenozoospermia, which represents a more severe combined defect in sperm count and motility, was considerably higher among urban men (28.1%) compared to rural men (19.6%). Azoospermia showed minimal difference between the two groups (5.0% in urban vs 4.5% in rural), suggesting that severe spermatogenic failure may not be strongly influenced by geographic or environmental variation.

One of the key findings in this study was the significantly lower sperm concentration observed among urban men. This result aligns with previous studies that have reported reduced sperm counts in populations exposed to urban environmental conditions. Zhou et al. demonstrated that men residing in urban areas with higher levels of air pollution had significantly lower sperm concentrations compared to those in rural areas.[13] Similarly, large-scale epidemiological studies have identified geographic variations in semen quality, with industrialized and urban regions often showing poorer parameters.[14,15] The higher percentage (28.1%) observed in the present study among urban men falls within this reported range, reinforcing the role of environmental and lifestyle factors.

Air pollution, in particular, has emerged as a major contributor to impaired semen quality. Several systematic reviews and meta-analyses have confirmed that exposure to pollutants such as PM2.5, PM10, and nitrogen dioxide is associated with reduced sperm concentration, motility, and increased DNA fragmentation.[16-19] These pollutants induce oxidative stress, which damages sperm membranes and DNA, thereby impairing spermatogenesis and sperm function. Lafuente et al. reported that most studies evaluating air pollution found at least one semen parameter to be adversely affected.[20]

In addition to sperm concentration, this study also found significantly reduced progressive motility among urban men. Sperm motility is a critical determinant of fertility, and its impairment has been strongly linked to oxidative stress and environmental toxicity. Studies by Jurewicz et al. and Kumar et al. have highlighted that environmental exposures, particularly air pollution and chemical toxins, are associated with decreased sperm motility.[11,4]

These findings support the hypothesis that urban environmental conditions may impair not only sperm production but also sperm function.

Lifestyle factors further contribute to the observed differences between urban and rural populations. In the present study, smoking and alcohol consumption were significantly more prevalent among urban men. Smoking has been shown to reduce sperm concentration, motility, and morphology through increased oxidative stress and DNA damage.[4] Similarly, alcohol consumption has been linked to hormonal imbalance and impaired spermatogenesis.

Another important finding of this study was the higher prevalence of oligoasthenozoospermia among urban men. This combined abnormality indicates a more severe impairment of spermatogenesis and sperm function. Similar patterns have been reported in studies evaluating environmental and occupational exposures. Kleshchev et al. found that men living in polluted urban areas exhibited increased sperm morphological defects and DNA fragmentation along with reduced motility.[21] This suggests that multiple semen parameters may be simultaneously affected in urban populations due to cumulative environmental insults.

In contrast, rural men in this study demonstrated relatively better semen parameters. This observation

is supported by studies suggesting that lower exposure to industrial pollutants and a more physically active lifestyle may contribute to improved reproductive health in rural populations.[14] Interestingly, the prevalence of azoospermia was similar in both groups, suggesting that severe spermatogenic failure may not be significantly influenced by environmental or lifestyle factors alone. This finding is consistent with previous studies indicating that azoospermia is often related to genetic, congenital, or obstructive causes rather than environmental exposure.[22]

The findings of this study are also supported by broader reviews on regional differences in semen quality. Rahban et al. emphasized that both environmental and lifestyle factors, beginning from fetal life to adulthood, play a critical role in determining semen quality.[14] Similarly, recent narrative reviews have highlighted that declining sperm parameters globally are likely multifactorial, involving environmental pollution, obesity, sedentary lifestyle, and endocrine disruption.[23]

The strengths of the present study include a relatively large sample size and the use of standardized WHO guidelines for semen analysis, ensuring reliability and comparability of results. However, certain limitations should be acknowledged. The study was hospital-based and may not represent the general population. Additionally, detailed quantification of environmental exposures such as pollution levels and pesticide exposure was not performed. Future studies incorporating environmental monitoring and biomarker analysis would provide a more comprehensive understanding of causal relationships.

CONCLUSION

Urban men demonstrated comparatively poorer semen parameters, particularly sperm concentration and motility, than rural men. Environmental pollution, unhealthy lifestyle practices, and occupational exposures likely contribute to these differences. Addressing modifiable risk factors through awareness and preventive strategies is essential to improve male reproductive health and fertility outcomes.

Declaration

Conflict of Interest: There is no conflict of interest.

Ethical Approval: Ethical approval was taken from institutional ethical committee.

Informed Consent: Informed written consent was obtained from all the study participants.

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