Original Article

Effect of Cigarette Smoking on Semen Parameters among Male Partners Attending GarbhaGudi IVF Centre, Bengaluru: A Retrospective Cross-sectional Analytical Study

Amera Afroz[1], D. Chandipriya[2], Lavanya C[3]

[1]Assistant Professor, Department of Anatomy, Government Medical College, Nalgonda, Telangana, India. [2]Assistant Professor, Department of Anatomy, Government Medical College, Khammam, Telangana, India. [3]Assistant Professor, Department of Anatomy, Government Medical College, Suryapet, Telangana, India

Abstract

Background: Cigarette smoking is a common and modifiable lifestyle exposure among men of reproductive age. Although its systemic health effects are well established, its relationship with semen quality remains clinically important because semen analysis is a key component of male infertility evaluation. The aim is to compare semen parameters between smokers and non-smokers among male partners attending an in vitro fertilisation centre. **Material and Methods:** This retrospective cross-sectional analytical study was conducted in the Department of Clinical Embryology, GarbhaGudi IVF Centre, Bengaluru, from January 2021 to July 2021. A total of 300 men with a history of infertility for at least 1 year were included. Participants were grouped according to smoking status into smokers (n=150) and non-smokers (n=150). Demographic information and semen parameters, including semen volume, pH, sperm concentration, motility, morphology, and white blood cell count, were analysed. Data were tested for normality using the Shapiro-Wilk test and compared using the independent samples t-test; categorical macroscopic findings were assessed using the Chi-square test when applicable. **Results:** The overall mean age of the participants was 34.9 ± 5.2 years. Smokers and non-smokers had comparable mean age (34.4 ± 4.6 vs 35.4 ± 5.7 years; p=0.10) and semen volume (2.6 ± 1.2 vs 2.7 ± 1.4 mL; p=0.60). Sperm concentration was numerically lower in smokers than in non-smokers (51.7 ± 29.7 vs 55.9 ± 35.2 million/mL), but the difference was not statistically significant (p=0.26). Total motility, progressive motility, normal morphology, total abnormal morphology, and WBC counts were also statistically comparable. Statistically significant differences were observed for pH (p=0.01), head defects (p=0.04), neck/mid-piece defects (p=0.02), and tail defects (p=0.01). Macroscopic semen viscosity and colour showed no meaningful between-group difference. **Conclusion:** In this cohort of infertile male partners, smoking status was associated with statistically significant differences in semen pH and selected morphology indices, whereas semen volume, sperm concentration, motility, normal morphology, and WBC counts did not differ significantly. The findings support routine assessment of smoking exposure during male infertility work-up and reinforce the need for structured smoking cessation counselling as part of reproductive health care.

Keywords: Male infertility; semen analysis; cigarette smoking; sperm motility; sperm morphology; IVF centre; reproductive health.

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Introduction

Tobacco smoking remains a major public health challenge despite continuous anti-smoking campaigns, regulatory measures, and public awareness programmes in several countries. It contributes substantially to cardiovascular disease, chronic respiratory disease, malignancy, and premature mortality, thereby creating a long-term clinical and economic burden on health systems.[1-3] Global tobacco-control strategies have improved surveillance and prevention policies, yet smoking continues to persist as a preventable exposure among many adult populations.[7] In addition to its established systemic effects, smoking has gained increasing attention in reproductive medicine because lifestyle-related factors are now frequently recognized during the evaluation of infertile couples.

Male infertility is a multifactorial condition influenced by genetic factors, endocrine abnormalities, genital tract infections, varicocele, obesity, occupational exposures, environmental toxins, and lifestyle practices. Psychological distress is also common among infertile men and can further affect clinical consultation, treatment adherence, and quality of life.[4] The American Society for Reproductive Medicine defines infertility as failure to achieve pregnancy after a defined period of regular unprotected intercourse, and male factor abnormalities contribute significantly to the overall infertility burden.[5]

Address for correspondence: Dr. Amera Afroz, Assistant Professor, Department of Anatomy, Government Medical College, Nalgonda, Telangana, India.
E-mail: amera.afroz@gmail.com

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However, awareness among men regarding fertility-related risk factors remains inadequate, particularly for modifiable exposures such as smoking, obesity, heat exposure, alcohol intake, and delayed health-seeking behavior.[6]

Smoking is clinically important in male infertility because it is a potentially reversible risk factor. Tobacco smoke contains nicotine, carbon monoxide, cadmium, lead, and polycyclic aromatic hydrocarbons, all of which can interfere with reproductive function. These substances can impair spermatogenesis through oxidative stress, endocrine disruption, accessory gland dysfunction, sperm membrane damage, mitochondrial impairment, and DNA fragmentation. The carcinogenic potential of active cigarette smoking has also been demonstrated in large epidemiological analyses, supporting the wider biological toxicity of tobacco exposure beyond the respiratory and cardiovascular systems.[8] In the context of fertility, such toxic effects may reduce the functional capacity of spermatozoa even when routine semen values appear only mildly altered.

Semen analysis remains the primary laboratory investigation for assessing the male partner in infertility evaluation. Standard semen parameters include semen volume, pH, sperm concentration, motility, and morphology. Although conventional semen analysis does not fully assess sperm DNA integrity, fertilizing capacity, or oxidative stress status, it provides a practical and clinically interpretable profile of male reproductive potential. Even moderate changes in sperm concentration, progressive motility, or normal morphology can influence counselling, treatment planning, and decisions related to assisted reproductive technology.

Previous studies have reported inconsistent associations between smoking and semen quality. Some investigators have observed reduced sperm concentration, poor motility, abnormal morphology, and increased seminal leukocytes among smokers, whereas others have found weaker or statistically non-significant associations. These differences may be related to variation in smoking intensity, duration of exposure, abstinence interval, age, alcohol use, body mass index, comorbidities, and laboratory methods. Therefore, centre-specific data remain useful for understanding the reproductive profile of smokers in infertility practice.

The present study was undertaken to compare semen parameters between smokers and non-smokers among male partners attending GarbhaGudi IVF Centre, Bengaluru. The study aimed to evaluate group-wise differences in routine semen parameters and to provide clinically relevant evidence for counselling male partners regarding smoking as a modifiable reproductive risk factor.

Materials and Methods

Study design and setting: This was a retrospective cross-sectional analytical study conducted in the Department of Clinical Embryology, GarbhaGudi IVF Centre, Bengaluru. The study period extended from January 2021 to July 2021. The available clinical and laboratory records of male partners attending the infertility clinic during the study period were reviewed.

Study population: Men who had a history of infertility for at least 1 year and who underwent semen analysis as part of routine infertility evaluation were considered for the study. A total of 300 men were included. Based on the recorded smoking history, participants were categorised into two equal groups: smokers (n=150) and non-smokers (n=150).

Clinical and laboratory variables: The study variables included age, semen volume, pH, sperm concentration, total motility, progressive motility, non-progressive motility, non-motile sperm percentage, normal sperm morphology, head defects, neck/mid-piece defects, tail defects, total abnormal morphology, and white blood cell count. Macroscopic findings such as semen viscosity and colour were also summarised.

Semen sample processing: Semen colour was observed immediately after sample collection, and volume was measured using a graduated test tube. Semen reaction was assessed by measuring pH. After ejaculation into the collection vessel, the sample was kept at room temperature and liquefaction was monitored up to 90 minutes. Total sperm count was calculated using a Neubauer chamber. Motility was assessed by counting motile and immotile spermatozoa in randomly selected microscopic fields under the 20X objective until at least 200 spermatozoa were counted. A minimum of five microscopic fields was examined. Sperm morphology was evaluated using semen smears prepared by the feathering technique.

Statistical analysis: Data were coded, entered into a Microsoft Excel worksheet, and analysed using SPSS version 21. Descriptive statistics were presented as mean and standard deviation for continuous variables and as number and percentage for categorical variables. The Shapiro-Wilk test was used to examine normality assumptions. Depending on data type and distribution, variables were compared using the independent samples t-test or Chi-square test. A p-value <0.05 was considered statistically significant.

Ethical considerations: The study was based on a retrospective review of available clinical and laboratory records. No direct patient interaction or intervention was involved during the study. Informed consent had been obtained from participants at the time of sample collection for diagnostic and research purposes. Patient confidentiality was strictly maintained throughout the study, and all data were anonymized before analysis.

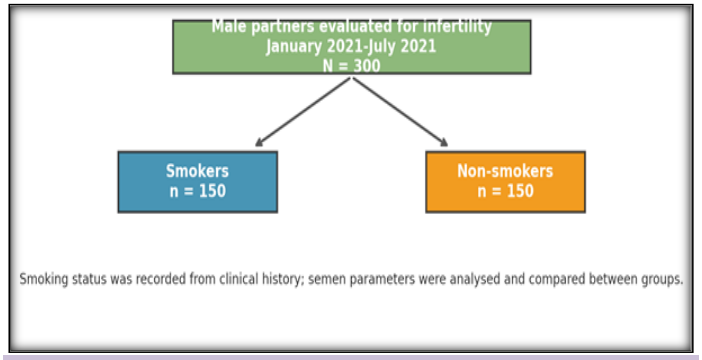

Figure 1: Study flow diagram showing grouping of participants by smoking status.

Results

A total of 300 male partners evaluated for infertility were included in the analysis. The participants were distributed

equally into smokers and non-smokers, with 150 men in each group. The overall mean age of the study population was 34.9 ± 5.2 years, and the age range was 21 to 52 years. The mean age was slightly lower among smokers than non-smokers; however, this difference was not statistically significant.

The descriptive semen profile of smokers and non-smokers is presented separately to allow a clearer appreciation of the range, mean, and variability of each parameter. The group-wise pattern showed broadly comparable semen volume, motility profile, normal morphology, total abnormal morphology, and WBC count. Sperm concentration was numerically lower among smokers, but the difference did not reach statistical significance.

Table 1: Study group distribution and baseline age profile

Variable	Value	Percentage
Total study participants	300	100.0
Smokers	150	50.0
Non-smokers	150	50.0
Overall age, mean ± SD	34.9 ± 5.2 years	-
Age range	21-52 years	-
Smokers: age, mean ± SD	34.4 ± 4.6 years	-
Non-smokers: age, mean ± SD	35.4 ± 5.7 years	-

Footnote: SD = standard deviation. Percentages were calculated using the total sample size of 300 as the denominator.

Table 2: Age and semen parameters among infertile smoker men (n=150)

Sl. No.	Parameter	Minimum	Maximum	Mean	SD
1	Age (years)	24	48	34.4	4.6
2	Semen volume (mL)	0.5	7	2.6	1.2
3	pH	7.2	8.0	7.3	0.1
4	Sperm concentration (million/mL)	0.9	110	51.7	29.7
5	Total motility (%)	10	85	55.3	16.0
6	Progressive motility (%)	0	72	41.7	16.8
7	Non-progressive motility (%)	0	36	13.4	5.5
8	Non-motile sperm (%)	15	90	44.9	15.7
9	Normal morphology (%)	0	4	2.4	0.9
10	Head defects	25	176	109.3	35.0
11	Neck/mid-piece defects	10	161	59.5	36.2
12	Tail defects	10	86	38.1	20.3
13	Total abnormal morphology (%)	96	100	97.6	0.9
14	WBC	0	8	2.2	1.2

Footnote: Values are expressed as mean ± standard deviation unless specified. WBC = white blood cells.

Table 3: Age and semen parameters among infertile non-smoker men (n=150)

Sl. No.	Parameter	Minimum	Maximum	Mean	SD
1	Age (years)	21	52	35.4	5.7
2	Semen volume (mL)	0.3	6	2.7	1.4
3	pH	7.2	7.6	7.3	0.1
4	Sperm concentration (million/mL)	3	210	55.9	35.2
5	Total motility (%)	5	82	55.6	15.3
6	Progressive motility (%)	0	70	41.6	17.0
7	Non-progressive motility (%)	3	30	13.9	5.7
8	Non-motile sperm (%)	18	95	44.4	15.3
9	Normal morphology (%)	0	6	2.4	1.0
10	Head defects	4	176	117.4	32.5
11	Neck/mid-piece defects	10	151	69.6	37.0
12	Tail defects	10	94	44.3	21.0
13	Total abnormal morphology (%)	47	100	97.2	4.3
14	WBC	0	12	2.3	1.6

Footnote: Values are expressed as mean ± standard deviation unless specified. WBC = white blood cells.

Between-group comparison demonstrated that semen volume, sperm concentration, total motility, progressive motility, non-progressive motility, non-motile sperm percentage, normal morphology, total abnormal morphology, and WBC count were not statistically different between smokers and non-smokers. Significant differences were observed for pH and selected morphology indices, namely head defects, neck/mid-piece defects, and tail defects.

Table 4: Comparative analysis of age and semen parameters between smokers and non-smokers

Sl. No.	Parameter	Smokers Mean ± SD	Non-smokers Mean ± SD	t-value	p-value	Interpretation
1	Age (years)	34.4 ± 4.6	35.4 ± 5.7	-1.6	0.10	Not significant
2	Semen volume (mL)	2.6 ± 1.2	2.7 ± 1.4	-0.6	0.60	Not significant
3	pH	7.3 ± 0.1	7.3 ± 0.1	-2.8	0.01	Significant
4	Sperm concentration (million/mL)	51.7 ± 29.7	55.9 ± 35.2	-1.1	0.26	Not significant
5	Total motility (%)	55.3 ± 16.0	55.6 ± 15.3	-0.2	0.87	Not significant
6	Progressive motility (%)	41.7 ± 16.8	41.6 ± 17.0	0.1	0.96	Not significant

7	Non-progressive motility (%)	13.4 ± 5.5	13.9 ± 5.7	-0.8	0.45	Not significant
8	Non-motile sperm (%)	44.9 ± 15.7	44.4 ± 15.3	0.3	0.76	Not significant
9	Normal morphology (%)	2.4 ± 0.9	2.4 ± 1.0	-0.2	0.85	Not significant
10	Head defects	109.3 ± 35.0	117.4 ± 32.5	-2.1	0.04	Significant
11	Neck/mid-piece defects	59.5 ± 36.2	69.6 ± 37.0	-2.4	0.02	Significant
12	Tail defects	38.1 ± 20.3	44.3 ± 21.0	-2.6	0.01	Significant
13	Total abnormal morphology (%)	97.6 ± 0.9	97.2 ± 4.3	1.2	0.20	Not significant
14	WBC	2.2 ± 1.2	2.3 ± 1.6	-0.7	0.49	Not significant

Footnote: p-values were calculated using the independent samples t-test. $p<0.05$ was considered statistically significant. The mean pH values appear similar after rounding to one decimal place.

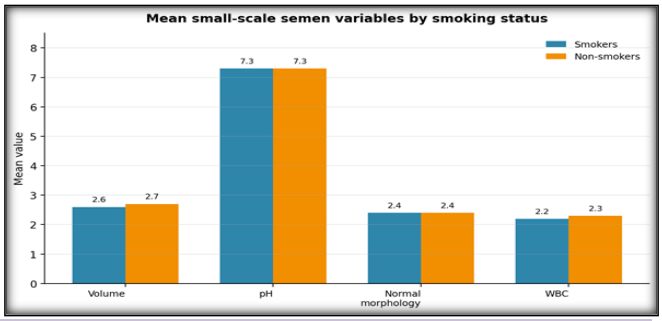

Figure 2: Mean small-scale semen variables by smoking status.

[Figure 2] shows that semen volume, pH, normal morphology, and WBC count were closely comparable between the two groups when viewed as mean values. The statistically significant pH difference in Table 4 should therefore be interpreted with caution because the rounded group means were similar.

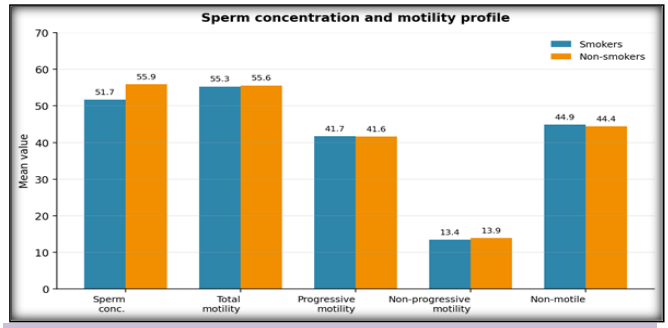

Figure 3: Sperm concentration and motility profile among smokers and non-smokers.

Sperm concentration was lower among smokers, whereas total motility and progressive motility were nearly identical between groups. None of the concentration or motility-related variables showed statistical significance in the between-group comparison.

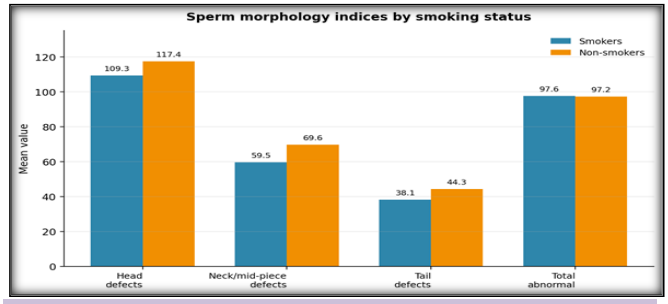

Figure 4: Morphology indices among smokers and non-smokers.

Morphology-related indices showed statistically significant differences for head defects, neck/mid-piece defects, and tail defects. In the available dataset, the mean values for these defect categories were numerically higher among non-smokers; therefore, the direction of association should not be overinterpreted as a direct smoking effect without adjustment for additional clinical variables.

Macroscopic semen assessment showed no meaningful difference in viscosity or colour between smokers and non-smokers. Normal viscosity was recorded in 95.3% of smokers and 94.0% of non-smokers, while high viscosity was recorded in 4.7% and 6.0%, respectively. Whitish grey semen colour was observed in 99.3% of participants in both groups, and pale yellow colour was noted in 0.7% of participants in both groups.

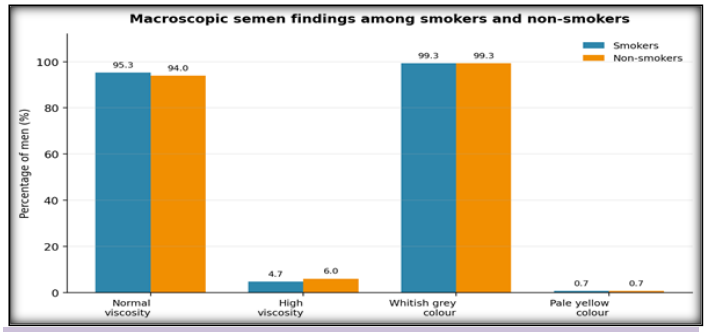

Figure 5: Macroscopic semen findings among smokers and non-smokers.

Discussion

The present study compared semen parameters between smokers and non-smokers attending GarbhaGudi IVF Centre, Bengaluru. The major finding was that most conventional semen parameters, including semen volume, sperm concentration, total motility, progressive motility, normal morphology, total abnormal morphology, and seminal WBC count, did not differ significantly between the two groups. Statistically significant differences were observed in semen pH and selected morphology defect indices. However, the rounded pH values were almost similar, and some morphology defect values were numerically higher among non-smokers. Therefore, these findings should be interpreted cautiously, giving importance not only to statistical significance but also to clinical relevance and direction of effect.

Smoking is a well-established systemic risk factor and has been linked with adverse cardiovascular outcomes, including incident heart failure.[9] Its reproductive effects are biologically plausible because cigarette smoke contains nicotine, cadmium, lead, carbon monoxide, and several oxidant compounds that can interfere with spermatogenesis, accessory gland function,

mitochondrial activity, and sperm membrane integrity. Although the present study did not demonstrate a major adverse effect of smoking on most routine semen variables, the absence of large differences does not exclude subtle functional sperm damage, particularly DNA fragmentation or oxidative stress, which were not assessed in this analysis.

Semen volume was nearly comparable between smokers and non-smokers in the present cohort. Earlier studies have shown variable results regarding the effect of smoking on semen volume and sperm density. Lewin et al. reported adverse effects of smoking on sperm concentration and motility, suggesting that tobacco exposure can impair semen quality in selected populations.[10] Similarly, Zhang et al. observed poorer semen parameters among infertile smokers in Shandong, China.[12] In contrast, the present study showed only a numerically lower sperm concentration among smokers, without statistical significance. This difference may be due to variation in smoking intensity, duration of exposure, abstinence interval, and background infertility causes.

Motility parameters were also similar between smokers and non-smokers. This finding differs from studies that reported reduced sperm motility among smokers.[10,13] Zhang et al. documented decline in semen quality and increased leukocytes with cigarette smoking among infertile men.[13] Pullanna et al. also reported adverse effects of cigarette smoking on semen parameters, including motility-related indices.[14] The lack of significant motility difference in the present study may be explained by the binary classification of exposure as smoker or non-smoker, without subgrouping participants according to mild, moderate, or heavy smoking status.

Morphology findings in the present study require balanced interpretation. Significant differences were seen in head defects, neck/mid-piece defects, and tail defects, but the mean defect values were numerically higher among non-smokers. Therefore, the data do not support a direct conclusion that smokers had greater morphology abnormalities in this cohort. Vogt et al. compared sperm quality among healthy smokers, ex-smokers, and never-smokers and showed that smoking-related effects may vary across exposure groups.[11] Future studies should apply strict morphology criteria, inter-observer validation, and detailed smoking exposure assessment to clarify this association.

The significant difference in semen pH, despite similar rounded mean values, is likely to reflect small distributional variation rather than a clinically meaningful difference. Semen pH can be influenced by seminal vesicle and prostatic secretions, infection, inflammation, abstinence duration, and laboratory timing. Since infection markers and accessory gland parameters were not comprehensively evaluated, this observation should be treated as exploratory.

Overall, the findings suggest that smoking status alone was not associated with large differences in routine semen parameters in this IVF-centre population. However, smoking remains a modifiable reproductive and systemic health risk. Infertility clinics should continue to document smoking status and provide cessation counselling, as benefits may extend beyond semen quality to cardiovascular, respiratory, oncological, and general health outcomes.[9,14]

Limitations

The study was retrospective and cross-sectional; hence, temporality and causality could not be established.Smoking exposure was not quantified according to duration, number of cigarettes per day, or pack-years. Potential confounders such as BMI, alcohol intake, abstinence period, varicocele, genital tract infection, comorbidities, occupational exposure, and hormonal profile were not adjusted in the available dataset.The study was conducted at a single IVF centre, and the findings may not be directly generalisable to all men in the community. Advanced sperm function tests such as sperm DNA fragmentation, reactive oxygen species, and oxidative stress markers were not included.

Conclusion

Among infertile male partners attending an IVF centre, cigarette smoking status was associated with statistically significant differences in semen pH and selected morphology indices, while semen volume, sperm concentration, motility, normal morphology, total abnormal morphology, and WBC count did not differ significantly between smokers and non-smokers. Smoking assessment and cessation counselling should be integrated into routine male infertility evaluation because tobacco use remains a preventable and clinically relevant reproductive health exposure.

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Conflicts of interest

There are no conflicts of interest.

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