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Original Research Article

Seasonal variation of human semen parameters: a retrospective study in Chennai, Tamil Nadu

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ABSTRACT

Background: Infertility in humans is a prevalent disorder that arises from several primary or secondary reasons. Regarding the latter, many seasonal and meteorological trends have been proposed as potential contributors. This study set out to determine whether the functional properties of semen samples kept in a secondary centre database showed any signs of a potential seasonal trend.
Methods: Retrospective analysis was performed on the 1830 consecutive sperm analysis reports that were gathered at the Institute of Reproductive Medicine and Women's Health over the course of a year (2020-2024). Microscopic, macroscopic examinations were included in the reports. Season of sample collection was used to examine data for various parameters. The assessment of continuous variables should be done using the ANOVA test. Additionally, a regression analysis and chi-squared will be carried out to determine the significant variation caused by season on semen parameter.
Results: Seasonal variations significantly impact sperm concentration and total sperm count, with temperature changes across seasons being a key factor. However, motility, morphology, and defect parameters remain stable and unaffected by temperature. Environmental factors like temperature should be considered in fertility assessments and treatments.
Conclusions: In conclusion, this thesis demonstrates that semen quality is significantly influenced by seasonal variations, with cooler temperatures associated with improved sperm concentration and total count, as indicated by statistically significant p values ($p<0.05$) for these parameters. The p values for sperm concentration ($p=0.0280$) and total sperm count ($p=0.0363$) confirm a significant relationship with seasonal temperature changes. In contrast, parameters such as motility and morphology remain relatively stable across seasons, as evidenced by non-significant p values ($p>0.05$).

Keywords: Chennai, Macroscopic examination, Microscopic examination, Season, Semen analysis, Temperature

INTRODUCTION

Infertility is a significant global concern, with male factors accounting for approximately half of all cases.[1] Routine semen analysis has been the cornerstone of male infertility diagnosis for decades, yet it offers limited information beyond identifying absolute abnormalities like azoospermia or asthenozoospermia. Despite its importance, current semen analysis methods often fall short in predicting fertility potential, particularly in cases where men with seemingly normal sperm parameters are diagnosed with idiopathic infertility. This limitation underscores the need for more nuanced diagnostic approaches that can provide better guidance for treatment.[2,3]

Environmental factors, including seasonal variations, are increasingly recognized as potential influences on male fertility.[4,5] Changes in climate, particularly in regions with pronounced seasonal patterns, can affect endogenous hormonal axes, potentially leading to secondary infertility issues. Chennai, with its distinct tropical climate characterized by hot seasons, monsoons, and post-monsoon periods, presents an ideal setting to study these environmental impacts on semen quality.[6]

This study aims to investigate the potential effects of seasonal variations on semen quality in Chennai.[7] By analysing data from 1,830 participants across different seasons, the study seeks to identify abnormalities in semen characteristics and their potential implications for diagnosing and treating male infertility. The findings could provide valuable insights into how environmental factors contribute to fertility issues, thereby improving the accuracy and effectiveness of infertility diagnoses and intervention.

METHODS

This retrospective study was conducted at the Institute of Reproductive Medicine & Women's Health (IRMWH) over a six-year period, from January 2018 to December 2024. The analysis focused on spermogram samples collected from a large, randomly selected cohort of patients. To ensure consistency and accuracy in the data, only samples obtained from patients who adhered to a specified abstinence period of two to seven days prior to sample collection were included in the study. Any samples with reported contamination or handling errors were excluded from the analysis.

Patients were instructed to follow a standardized protocol for sample collection. They were required to cleanse their hands thoroughly with water, urinate, and then clean the genital area with water before drying it with a tissue. Care was taken to avoid any contamination with urine, water, or soap during the collection process. Semen samples were collected via masturbation into sterile containers provided by the clinic. Upon collection, the samples were allowed to liquefy for 30 minutes at room temperature, with a maximum allowable time of 60 minutes for samples with high viscosity.

After liquefaction, each sample was carefully mixed using a sterile pipette. Viscosity was assessed by drawing the semen into a syringe and measuring the length of any thread formed when a drop was released. The pH of the sample was measured using a pH strip. A small droplet of the semen was then placed onto a Makler chamber and examined under a microscope at 40x magnification. This examination assessed sperm concentration, motility, morphology, and the presence of agglutination, aggregation, and other cellular components. The morphological evaluation included scoring the head, midpiece, and tail of the spermatozoa.

The data were categorized based on the season during which the sample was collected, with seasons defined as follows: Postmonsoon/Winter (January-February), Summer (March-June), Southwest Monsoon (July-September), and Northeast Monsoon (October-December). Statistical analysis was conducted using Microsoft Excel. Continuous variables were analysed using ANOVA and regression analysis, while categorical data were analysed using the chi-squared test. The study aimed to identify any significant seasonal variations in semen quality across the defined seasonal groups.

Table 1: Classification of season in Chennai.

Season	Months	Group	Celsius	Avg. celsius
Post-monsoon /winter	Jan-Feb	1	20-30	25
Summer	Mar-Jun	2	35	35
South west monsoon	Jul-Sep	3	25-30	25
North east monsoon	Oct-Dec	4	25-30	25

Ethical approval for the study was obtained from the Institutional Ethics Committee of the Institute of Reproductive Medicine and Women's Health (IRMWH). All patient data were anonymized to maintain confidentiality.

RESULTS

To effectively interpret the data on semen parameters across different seasons, a combined analysis of the means and standard deviations for both macroscopic and microscopic sperm characteristics is necessary.

The mean abstinence periods are relatively similar across all seasons, indicating stability in this factor within the population studied. However, the summer season exhibits a broader range of values, suggesting greater variability in individual behaviours or sampling during this time. This variability could be due to changes in personal habits or external factors influencing the duration of abstinence. Semen volume remains fairly consistent across all seasons, with only slight variations in mean values. These minor differences in volume are unlikely to be statistically significant, as the small standard deviations indicate minimal variability within each season. This consistency suggests that semen volume is not significantly influenced by seasonal changes in the environment or lifestyle factors. The pH of the semen samples shows more variability, particularly during the summer, which could point to inconsistent sample conditions or biological variations within this season, possibly influenced by higher temperatures and humidity. The other seasons display more consistent pH values, reflecting stable conditions for semen quality during those periods.

When examining microscopic sperm parameters, sperm concentration remains relatively constant throughout the year, with the lowest concentration observed in the summer (31.65±28.82) and the highest during the Northeast monsoon (35.79±30.42). Despite these fluctuations, the standard deviations indicate a considerable degree of variability within each season, suggesting that individual differences in sperm concentration are more pronounced than seasonal trends. The total sperm count shows an inverse pattern compared to concentration, with the Northeast monsoon having the lowest mean count (82.09±70.79) and the summer the highest (95.00±85.82). This could imply that while sperm concentration is lower in the summer, the total count may be higher due to larger ejaculate volumes or other compensatory factors. Motility parameters reveal that overall motility and rapid progressive motility are highest during the Southwest monsoon (48.32±17.51 and 7.73±7.06, respectively), suggesting that this season may provide the most favourable conditions for sperm movement and, potentially, fertilization. In contrast, the Northeast monsoon shows the lowest rapid progressive motility (6.51±5.55), indicating that this season may be less conducive to optimal sperm function.

Table 2: Standard deviation and average for semen parameters across 4 season.

STD±AVG		Post monsoon	Summer	Southwest monsoon	Northeast monsoon
N	**1830**	**430**	**456**	**501**	**443**
Abstinence	2-7 days	3.06±0.73	3.43±2.11	3.22±0.85	3.23±1.07
Volume	1.5-2 ml	2.44±1.25	2.59±1.94	2.53±1.29	2.33±1.26
pH	7.2-7.8	7.76±3.35	9.37± 34.36	7.66±3.03	7.58±0.30
Concentration	16M/ml	34.86±30.26	31.65±28.82	34.91±30.68	35.79±30.42
Total count	39M/ml	84.00±87.80	95.00±85.82	85.83±94.38	82.09±80.79
Total motility	42%	46.34±16.72	48.32±17.51	48.22±16.02	46.43±16.85
Rapid progressive	30%	7.14±5.34	7.39±4.65	7.73±7.06	6.51±5.55
Slow progressive	%	24.31±9.17	25.92±10.34	26.43±18.08	25.03±10.35
Non progressive	1%	18.38±27.21	17.11±7.05	17.39±25.44	17.42±9.10
Non motile	%	52.34±15.00	50.96±30.07	50.69±14.63	51.88±15.28
TMSC	M	31.86±38.30	30.05±37.39	38.13±48.46	29.55±34.79
Normal morphology	>4%	1.78±0.88	1.85±2.23	2.01± 3.51	1.90±2.12
Head defect	%	44.13±59.31	44.52±7.76	39.57±6.36	39.41±5.97
Neck defect	%	42.12±63.29	30.41±7.81	32.54±6.21	34.78±4.77
Tail defect	%	13.86±4.76	11.83±2.99	13.96±4.37	12.58±3.32
Cytoplasmic defect	%	10.54±2.75	10.97±8.44	13.69±29.58	10.04±1.94

Non-progressive motility and the proportion of non-motile sperm are relatively stable across all seasons, though notable deviations exist. The Northeast monsoon has the lowest non-progressive motility (17.42±9.10), while the post-monsoon period shows the highest (18.38±27.21). The summer season shows the highest proportion of non-motile sperm (50.96±30.07), which might reflect less favourable conditions during this time. Regarding morphology, all seasons exhibit low percentages of normal forms, with the Northeast monsoon having the lowest mean (1.90±2.12) and the Southwest monsoon the highest (2.01±3.51). This suggests that abnormal sperm morphology is a consistent issue throughout the year, with slight seasonal variations. Defects in sperm morphology, including head, neck, and tail abnormalities, show some seasonal trends. Head defects are highest in the summer (44.54±7.76) and lowest during the Northeast monsoon (39.41±5.97). Neck deformities peak in the post-monsoon period (42.12±63.29), while tail defects are most pronounced during the post-monsoon (13.86±4.76) and least during the summer (11.83±2.99). Cytoplasmic deficiencies are highest in the Southwest monsoon (13.69±29.58) and lowest during the post-monsoon period (10.54±2.75).

Seasonal variations have a significant impact on various semen parameters, with p-values indicating meaningful differences throughout the year. Appearance (p=0.0003) and viscosity (p=0.0003) show notable seasonal changes, particularly with aberrant appearance being least noticeable during the Southwest Monsoon and anomalous viscosity peaking post-monsoon. WBC counts (p=0.0001) and the presence of round cells (p=0.0000) exhibit significant fluctuations, with higher abnormalities observed in summer. Additionally, cell aggregation (p=0.0119) remains consistently low across seasons, while agglutination (p=0.0014) and pin heads (p=0.0045) are most irregular during the Southwest Monsoon. Overall, these results highlight significant seasonal impacts on semen parameters, emphasizing that the Southwest Monsoon often displays distinct deviations from other seasons.

The combined ANOVA and regression analyses reveal how seasonal variations and temperature affect semen parameters. ANOVA shows significant seasonal changes in parameters such as semen volume (p=0.0322) and neck defects (p=0.0473), though others like abstinence duration and tail defects have only marginal significance. Most parameters, including pH, concentration, total count, motility, and morphology, remain stable across seasons. Regression analysis confirms that temperature significantly influences pH (p=0.0037), sperm concentration (p=0.0280), and total sperm count (p=0.0363), with higher temperatures linked to increased pH and reduced sperm parameters. Despite these variations, motility, morphology, and various defects are not significantly affected by temperature, suggesting that while temperature impacts sperm quantity, it does not alter quality. This underscores the need to consider environmental factors in fertility assessments.

Table 3: Qualitative analysis on semen parameters across 4 season.

CHISQ		Post monsoon	Summer	Southwest monsoon	Northeast monsoon	P value
	n	**430**	**456**	**501**	**443**	
Appearance	Normal	351	358	443	375	0.0003
	Abnormal	79	98	58	68	
Viscosity	Normal	274	344	373	311	0.0003
	Abnormal	156	112	128	132	
WBC	Normal	129	101	157	158	0.0001
	Abnormal	301	355	344	285	
Round cells	Normal	129	101	157	158	0.0000
	Abnormal	301	355	344	285	
Aggregation	Normal	30	12	23	29	0.0119
	Abnormal	400	444	478	414	
Agglutination	Normal	51	25	46	50	0.0014
	Abnormal	379	431	455	393	
Pin heads	Normal	102	98	87	119	0.0045
	Abnormal	328	358	414	324	

Table 4: Quantitative analysis on semen parameters across season and temperature.

P	Units	RA	ANOVA
pH	7.2-8.0	0.2092	0.0037
Abstinence	2-7 days	0.0591	0.1422
Volume	1.4 ml	0.0322	0.3083
Concentration	16M/ml	0.1765	0.0280
Total count	39M/ml	0.8591	0.0363
Total motility	42%	0.8293	0.3928
Rapid progressive	30%	0.0842	0.7445
Slow progressive	%	0.3310	0.6474
Non progressive	1%	0.7770	0.4410
Non motile	%	0.5421	0.5624
TMSC	M	0.4760	0.6036
Normal morphology	>4%	0.5681	0.7589
Head defect	%	0.1686	0.3773
Neck defect	%	0.0473	0.4042
Tail defect	%	0.0887	0.2068
Cytoplasmic defect	%	0.3557	0.2068

DISCUSSION

The findings of this study reveal significant seasonal variations in semen parameters, with particular attention to the impact of environmental factors such as temperature and humidity. These variations are crucial to understanding male fertility, as semen quality directly influences reproductive outcomes.

The seasonal stability observed in abstinence periods suggests that the variations in semen quality are not significantly influenced by changes in abstinence duration. However, the broader range of values observed during the summer season could indicate that individual behaviours or external factors, such as lifestyle changes or environmental stressors, may contribute to variations in semen quality during this period. This finding aligns with previous studies that have documented the impact of environmental factors on semen parameters, particularly in warmer climates.[6,7]

Semen volume, which remained relatively consistent across seasons, suggests that this parameter is less sensitive to environmental changes. The minor fluctuations observed are consistent with earlier research that also reported minimal seasonal impact on semen volume.[5] This stability in semen volume is crucial, as it indicates that seasonal variations in other parameters are not due to changes in ejaculate volume but rather to other environmental or physiological factors.

The pH values exhibited more significant variability, particularly during the summer. This finding is consistent with previous studies that have shown environmental temperature can influence semen pH, potentially due to dehydration or altered physiological responses to heat.[14] The higher pH observed during the summer could be attributed to increased environmental temperatures and humidity, which have been shown to affect the physiological conditions of the male reproductive system.[15]

Sperm concentration and total sperm count demonstrated notable seasonal fluctuations, with the lowest concentrations observed during the summer and the highest during the Northeast monsoon. These findings are in line with studies that have reported decreased sperm concentration in warmer seasons, likely due to heat stress and oxidative damage to sperm cells.[4,16] The inverse relationship between concentration and total count, where higher total counts were observed in the summer, could be explained by compensatory mechanisms such as increased ejaculate volume or other factors that mitigate the effects of reduced concentration.

Motility parameters, particularly rapid progressive motility, peaked during the Southwest monsoon, indicating more favourable conditions for sperm movement during this season. This aligns with previous research showing that sperm motility is sensitive to environmental conditions, with cooler temperatures and higher humidity potentially enhancing motility.[19] Conversely, the lowest rapid progressive motility observed during the Northeast monsoon suggests that this season may present less optimal conditions for sperm function, possibly due to lower temperatures or other environmental factors that inhibit sperm movement.

Morphological analysis revealed low percentages of normal sperm forms across all seasons, with slight variations. These results support the findings of earlier studies that reported consistently low morphology percentages, with seasonal trends influencing the extent of abnormal forms.[13,17] The observed trends in head, neck, and tail defects suggest that these morphological abnormalities may be influenced by environmental stressors, with certain seasons exacerbating specific types of defects. For example, head defects were most pronounced in the summer, potentially due to heat stress, while neck and tail defects peaked during the post-monsoon period, possibly due to residual environmental effects from the preceding monsoon season.[3]

Qualitative analysis of semen parameters further highlights significant seasonal impacts. Abnormal appearance and viscosity were most noticeable post-monsoon, while WBC counts and round cells were significantly elevated during the summer. These findings are consistent with studies indicating that environmental factors, including temperature and humidity, can influence these qualitative parameters.[18] The increased cell aggregation, agglutination, and pinheads during the Southwest monsoon suggest that this season may present unique challenges to sperm quality, potentially due to the combined effects of temperature, humidity, and other environmental stressors.[20]

The combined ANOVA and regression analyses provided further insights into the relationship between seasonal variations, temperature, and semen parameters. The significant seasonal changes observed in semen volume and neck defects, along with the influence of temperature on pH, concentration, and total sperm count, underscore the importance of considering environmental factors in fertility assessments.[11] The lack of significant effects on motility, morphology, and various defects suggests that while temperature and seasonality impact sperm quantity, they may not have a profound effect on sperm quality, as defined by these parameters.

Infertility remains a significant concern globally, affecting a substantial portion of the population and presenting a multifaceted challenge to reproductive health. This comprehensive study aimed to investigate the potential seasonal variations in semen parameters and their association with environmental factors, particularly temperature, over a four-year period from 2020 to 2024. Conducted at the Institute of Reproductive Medicine and Women's Health, the study utilized a retrospective analysis of 1,830 consecutive sperm analysis reports, encompassing microscopic, macroscopic, and semen culture examinations.

The study revealed significant seasonal variations in sperm concentration and total sperm count. Notably, sperm concentration and count were higher in cooler seasons compared to warmer ones. This aligns with the hypothesis that lower ambient temperatures may be conducive to better spermatogenesis, possibly due to reduced oxidative stress and hormonal stability during cooler periods.[15,17]

Contrary to sperm concentration and total count, parameters such as motility, morphology, and the presence of defects remained relatively stable across different seasons. This suggests that while temperature influences overall sperm production, it does not significantly impact the structural and functional quality of the spermatozoa produced.[14,19]

The significant variation in pH with seasonal changes suggests that temperature influences semen pH. Higher temperatures in summer are associated with increased pH levels. Environmental temperatures might affect physiological conditions that, in turn, influence semen pH. These variations can have implications for sperm motility and overall fertility.[13]

Temperature emerged as a critical environmental factor influencing semen quality. The study's findings support the notion that optimal temperature ranges are essential for maintaining higher sperm concentration and total count. Extreme temperatures, both high and low, were found to be detrimental to semen quality, emphasizing the need for environmental considerations in fertility assessments and treatments.[16,18]

The results underscore the importance of considering seasonal and environmental factors when evaluating male fertility. Clinicians should be aware of these variations and possibly adjust the timing of semen collection and analysis to align with periods of optimal semen quality. This could enhance the accuracy of fertility assessments and improve outcomes in assisted reproductive technologies (ART).[20]

The findings of this study are consistent with previous research that has documented seasonal patterns in semen quality. Studies conducted in various geographical locations, including North India, Turkey, and China, have similarly reported improved semen parameters during cooler seasons.[15,17] This study adds to the growing body of evidence by providing comprehensive data from a four-year period and reinforcing the significance of environmental factors in male reproductive health.

The study's retrospective design allowed for the analysis of a large dataset over an extended period, providing robust and reliable results. The inclusion of multiple semen parameters and comprehensive statistical analyses (ANOVA and logistic regression) ensured a thorough examination of the data. Despite its strengths, the study has limitations that warrant consideration. The retrospective nature precludes the establishment of causality, and potential confounding factors, such as lifestyle and occupational exposures, were not accounted for. Additionally, the study was conducted in a specific geographical region, which may limit the generalizability of the findings to other populations.

This study has few limitations. In addition to the aforementioned limitations, this thesis also faces challenges related to the precision and consistency of data collection methods. The retrospective nature of the study means that the semen samples were collected and analyzed over several years, during which time there may have been variations in the equipment, techniques, and personnel involved. These inconsistencies could introduce measurement errors and affect the reliability of the results.[8]

Furthermore, while the study attempts to correlate seasonal temperature variations with changes in semen parameters, it does not account for other environmental factors such as humidity, pollution, or lifestyle changes that may also vary with the seasons and impact reproductive health.[9] The study also does not include a comprehensive analysis of the participants' medical histories, which could provide important context for interpreting the findings.

The lack of longitudinal data, where the same individuals are tracked over time, limits the ability to understand the long-term effects of seasonal changes on semen quality. Instead, the study relies on cross-sectional data, which may capture only temporary or situational changes rather than stable trends. Additionally, the use of averages in the analysis might obscure individual variability, making it difficult to apply the findings to all patients uniformly.[11]

Finally, while the study finds statistically significant relationships between temperature and certain semen parameters, the biological mechanisms underlying these relationships are not explored in depth. Without a clear understanding of these mechanisms, the results should be interpreted with caution, and further research is needed to validate and expand upon the findings.[12]

CONCLUSION

In conclusion, this thesis demonstrates that semen quality is significantly influenced by seasonal variations, with cooler temperatures associated with improved sperm concentration and total count, as indicated by statistically significant p-values ($p<0.05$) for these parameters. The p-values for sperm concentration ($p=0.0280$) and total sperm count ($p=0.0363$) confirm a significant relationship with seasonal temperature changes. In contrast, parameters such as motility and morphology remain relatively stable across seasons, as evidenced by non-significant p-values ($p>0.05$). The study underscores the importance of considering environmental factors, particularly temperature, in fertility assessments and treatments. Aligning semen collection and analysis with periods of optimal semen quality can enhance fertility evaluations and improve outcomes in assisted reproductive technologies. Despite the robust dataset and comprehensive analysis, future research should address potential confounding factors and explore the combined effects of other environmental variables to fully understand their impact on male reproductive health.

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