Original Article

Impact of Seasonal Variations on Semen Parameters: A Retrospective Analysis of Data from Subjects Attending a Tertiary Care Fertility Centre

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Abstract

Background: Seasonal variations in semen parameters have been detected in many previous studies, mostly conducted in the West and Mediterranean countries. Located in a tropical region, we have only three seasons – summer, winter and rainy season. Literature search did not reveal studies from Indian subcontinent. **Aims:** Our objective was to find if our climate produced seasonal variations in semen parameters such as sperm concentration (SC), total motile SC, morphology and vitality, which may have implications in fertility management. **Settings and Design:** This is a descriptive study, conducted at a tertiary level hospital. Semen analysis reports of male partners of all infertile couples during the 4-year period from 2019 to 2022 were analysed. **Materials and Methods:** The data were collected from records of all infertile couples registered for the treatment in the department during the study period. Semen analysis reports of male partners of all infertile couples attending outpatient department of the Reproductive Medicine Department during the 4-year period from January 2019 to December 2022 were collected. The data of azoospermic and severe oligospermic (<5 million/mL) men and those receiving hormone treatment were excluded. **Statistical Analysis Used:** Data were analysed using SPSS 23 and variables expressed as mean and standard deviation. Changes in mean values over years and over seasons were evaluated using *F*-test. *Post hoc* analysis was done using Sidak method. $P < 5\%$ was considered statistically significant. **Results:** The data of 2326 patients were analysed. SC was lowest during summer but was not statistically significant. Sluggishly motile sperm per cent was maximum in rainy season ($P = 0.002$). *Post hoc* analysis showed significant variations in summer samples compared to both rainy and winter seasons. Head defect (HD) and tail defects showed a significant seasonal variation ($P = 0.011$ and $P = 0.024$, respectively), lowest HD seen in rainy season. **Conclusion:** Semen parameters showed seasonal variations, with favourable features in colder climates, and may need to be considered in infertility management, especially if the male is oligospermic.

Keywords: *Seasonal variation, sluggishly motile, total motile sperm concentration, total sperm concentration*

Introduction

Seasonal variations in conception and childbirth have been linked to seasonal variations in semen parameters since a long time. Male factor infertility has

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been identified as the main or secondary cause in >40% of infertile couples. Changes in temperature and photoperiod were suggested to be the likely cause for the circannual variations observed in sperm parameters by various researchers.[1-4] Lowest values of sperm count were seen in summer, whereas peak values occurred in winter and spring, in the study by Politoff *et al*.[1] Substantial summer deterioration in semen quality-lower sperm concentration (SC), total sperm count, per cent motile sperm and total motile SC (TMSC) was found by Levin *et al*.[2] Both normozoospermic and oligozoospermic semen samples appeared to have better sperm parameters in spring and winter, in the study by Ozelci *et al*.,[3] Chen *et al*.[4] also found seasonal variations in SC and evidence of seasonal variation in both sperm motility and morphology. A large study conducted by Tendler *et al*.,[5] from a dataset of millions of hormone tests, suggested seasonal variations, with winter–spring peak in human functions, growth and reproduction. The effector hormones peak in winter–spring, whereas the regulating pituitary hormones peak months later, in summer, explaining the circannual clock.

Almost similar findings were seen in other studies where SC and quality were reduced in the summer months.[6,7] Peaks of high SC were seen in spring, with overall normal semen parameters in winter. Elevated summer heat may have an adverse effect on spermatogenesis, probably due to the inability of the testicles to thermoregulate properly. Besides elevated temperature, photoperiod (length of day) may also be a factor in in producing seasonal changes in semen quality. Days are longer in summer and shorter in winter. This change in photoperiod has a biological effect on the reproductive hormones in animals. The role of melatonin secretion at night and its influence on gonadotrophins may also play a role in seasonal sperm quality. In addition, lifestyle, physical activity and environmental changes may also affect semen parameters.

We are located in the tropical region, and the climate in our state is typically described as equatorial tropical climate. We have basically three seasons: winter – which starts after north-east monsoon in November and ends by late February; Summer – end of February to end of May and Monsoon – June to November (Southwest followed by north-east monsoon). Being a tropical climate however, there are not much extreme temperature fluctuations over the months.

Literature search did not reveal studies from the Indian subcontinent, though many studies were conducted in the West and Mediterranean countries. Our objective was to find if our climate too produced variations in semen parameters – total sperm count, SC, TMSC, morphology and vitality as was detected in the west; which can have implications in fertility management.

Materials and Methods

This was a hospital-based descriptive study conducted at the department of reproductive medicine, in a tertiary care centre.

The data were collected from records of all infertile couples registered for the treatment in the department during the study period. Semen analysis reports of male partners of all infertile couples attending outpatient department of the Reproductive Medicine Department during the 4-year period from January 2019 to December 2022 were collected. Sample size was not calculated as data of all samples analysed were included in the study.

The data of azoospermic and severe oligospermic (<5 million/mL) men and those receiving hormone treatment were excluded [Flowchart 1].

Semen was collected by masturbation after 2–3 days of abstinence for all patients. The specimen was allowed to liquefy in an incubator at 37°C and was analysed within 60 min after collection as per standard protocol.

The analysis was done by two andrology-trained technicians.

A routine semen analysis was performed which included the study variables – semen volume (SV), pH, SC, motility, sperm morphology and vitality and reported as per the WHO 2010 criteria.[8]

The data were grouped into three, based on the seasons prevailing in our state: December to February – Winter; March to May – Summer and June to November – Monsoon.

Data analysis

Data analysis was done using IBM, SPSS Version 27, Learning Resource Centre, Government Medical College, Thiruvananthapuram, Kerala, India. Semen parameters were expressed as mean and standard deviation (SD). Changes in mean values over years and over seasons were evaluated using *F*-test. *Post hoc* analysis was done using Sidak method. A $P < 0.05$ was considered statistically significant.

Ethical consideration

The institutional research committee approved the study, and ethical clearance was obtained from the human ethics committee of the institution. HEC NO: 10/02/2022/MCT. The ethical committee waived informed consent as the study used only anonymised data. The study strictly adhered to the principles of the Helsinki declaration (2013).

Results

The data of 2326 subjects were analysed [Flowchart 1]. The mean age was 35.3 years. Season-wise analysis of semen parameters is shown in Table 1.

SC showed an increasing trend from summer, through rainy to winter season, but was not statistically significant. There was no significant difference in the mean value of actively motile (AM) sperm per cent across the different seasons. Mean sluggishly motile (SM) sperm per cent was maximum in rainy season and minimum in summer. The mean number of SM sperms was significantly different in rainy and winter seasons as opposed to summer (P = 0.002; P = 0.035, respectively). Mean of non-motile (NM) and total motile (TM) sperm per cent did not show any significant difference across the three seasons. SV, total concentration (TC), TMSC and vitality also had no significant seasonal variations.

When sperm morphology was analysed, mean of normal forms (NF) per cent between seasons was not different. Head defects (HDs) per cent and tail defects (TD) per cent had highly significant seasonal variations [Figure 1]. However, for mid defects (MD) per cent, only a marginal variation was seen between seasons (P = 0.049). Lowest HD was found in rainy season, and its difference from summer and winter seasons was statistically significant (P = 0.011 and P = 0.024, respectively). There was an overall seasonal difference of seminal white blood cells (WBC/mL) (P = 0.035), with increase WBC/mL seen in summer as compared to winter.

Table 2 shows the year-wise variations in the semen parameters from 2019 to 2022.There was an increasing trend in the mean values of SC from 2019 to 2022. The values were higher in 2022 than in 2019 and were statistically significant (mean ± SD vs. mean ± SD; P = 0.003). When motility was considered, AM had no significant variation during the study period. SM showed an increase in trend over the periods, and it was statistically significant. Year-wise comparison showed a significant difference in SM values, except between 2020 and 2021 [Figure 2]. NM and TM per cent, SV

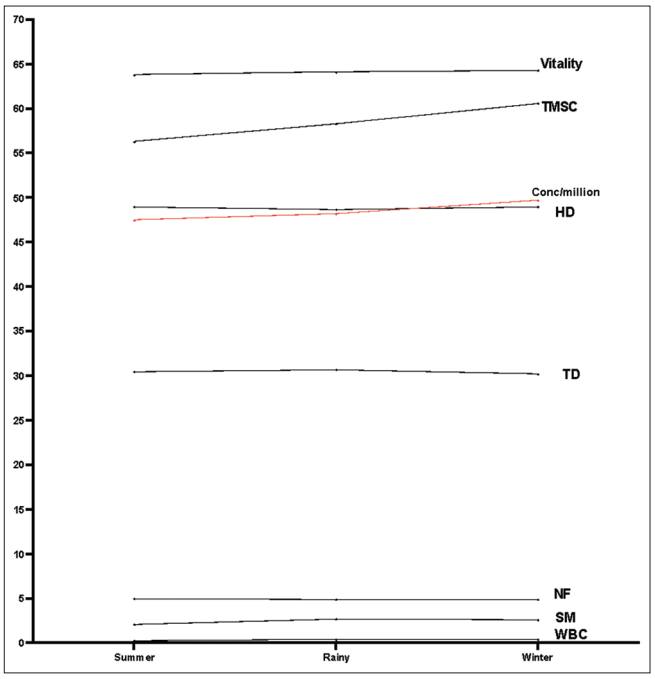


Figure 1: Line diagram depicting seasonal changes in semen parameters. TMSC = Total motile sperm concentration, HD: Head defects, TD: Tail defects, NF: Normal forms, SM: Sluggishly motile

Table 1: Descriptive statistics of semen parameters-season wise

	Mean±SD				*F*	*P*
	Summer	Rainy	Winter	Total		
Concentration/million	47.52±31.68	48.16±32.56	49.65±33.39	48.40±32.57	0.69	0.501
AM	54.44±17.07	53.76±18.70	54.45±18.51	54.10±18.27	0.41	0.662
SM	2.06±3.16	2.67±3.63	2.56±3.30	2.50±3.44	6.17	0.002
NM	43.54±16.84	43.57±18.36	42.99±18.32	43.41±17.99	0.23	0.794
TM	56.49±16.84	56.43±18.36	57.01±18.32	56.60±17.99	0.23	0.797
Volume/mL	1.94±0.91	2.01±0.93	2.04±0.94	2.00±0.93	1.88	0.153
TC	91.51±73.54	94.07±77.30	99.14±85.41	94.81±78.70	1.48	0.229
TMSC	56.32±52.10	58.25±56.20	60.59±56.38	58.41±55.29	0.88	0.414
Vitality (%)	63.81±16.25	64.10±17.81	64.29±17.75	64.08±17.43	0.11	0.896
NF	4.99±1.37	4.87±2.21	4.87±1.93	4.90±1.96	0.80	0.451
HD	49.01±2.23	48.65±3.30	49.03±2.82	48.84±2.95	4.54	0.011
MD	15.40±3.28	15.78±4.07	15.91±3.50	15.72±3.75	3.03	0.049
TD	30.52±3.61	30.70±4.28	30.15±3.7	30.51±3.99	3.75	0.024
WBC/million	0.27±0.75	0.36±0.80	0.38±0.82	0.34±0.79	3.37	0.035
Total	556	1152	618	2326		

AM=Actively motile, SM=Sluggishly motile, NM=Non-motile, TC=Total concentration, TM=Total motile, TMSC=TM sperm concentration, NF=Normal forms, HD=Head defects, MD=Mid-defects, TD=Tail defect, WBC=White blood cells, SD=Standard deviation

Table 2: Descriptive statistics of semen parameters year wise

	Mean±SD					*F*	Significant
	2019	2020	2021	2022	Total		
Concentration/million	45.00±30.45	48.38±30.33	49.78±33.03	51.05±35.23	48.40±32.57	4.60	0.003
AM	54.03±17.10	55.89±17.66	54.20±19.11	53.16±19.08	54.10±18.27	1.80	0.150
SM	1.64±2.92	2.34±3.02	2.71±3.54	3.35±3.86	2.50±3.44	31.40	0.000
NM	44.33±16.67	41.77±17.48	43.09±18.90	43.52±18.88	43.41±17.99	1.71	0.163
TM	55.67±16.67	58.24±17.48	56.91±18.90	56.50±18.87	56.60±17.99	1.71	0.162
Volume	2.04±0.95	2.04±0.89	2.00±0.91	1.93±0.93	2.00±0.93	1.58	0.135
TC	89.85±80.63	99.06±78.24	97.01±73.96	96.23±80.31	94.81±78.70	1.55	0.199
TMSC	53.55±51.98	61.67±54.78	60.93±54.21	60.03±59.53	58.41±55.29	2.90	0.033
Vitality (%)	62.05±16.67	64.68±17.02	64.38±18.25	65.76±17.60	64.08±17.43	5.69	0.001
NF	5.40±1.44	4.83±2.47	4.69±2.17	4.56±1.88	4.90±1.96	25.61	0.000
HD	48.83±3.02	48.38±2.85	48.81±3.68	49.11±2.15	48.84±2.95	4.92	0.002
MD	13.83±2.20	16.48±3.85	16.41±4.67	16.86±3.43	15.72±3.75	108.26	0.000
TD	31.83±2.56	30.27±3.97	30.30±5.17	29.36±3.81	30.51±3.99	50.01	0.000
WBC/million	0.14±0.32	0.46±1.00	0.42±0.95	0.43±0.86	0.34±0.79	24.45	0.000
Total	746.00	360.00	538.00	682.00	2326.00		

AM=Actively motile, SM=Sluggishly motile, NM=Non-motile, TC=Total concentration, TM=Total motile, TMSC=TM sperm concentration, NF=Normal forms, HD=head defects, MD=Mid defects, TD=Tail defect, WBC=White blood cells, SD=Standard deviation

and TC had no significant variation during the 4-year period. Mean TMSC was found to be lowest in 2019 and highest in 2020 with overall significance ($P = 0.033$).

Vitality showed an increasing trend during the study period [Figure 2], which was statistically significant ($P = 0.001$) and *post hoc* verification showed an increase between 2019 and 2022.

Morphology analysis showed a decreasing trend in mean NF per cent from 2019 to 2022, and the result was statistically significant ($P < 0.001$). *Post hoc* analysis showed a significant difference in the NF values between 2019 and 2020, 2021 and 2022. HD values showed an increasing trend except in 2020, and a statistical significance was obtained ($P = 0.002$). A significant increase was observed between 2020 and 2022 ($P < 0.001$). There was an overall increase in mean MD values from 2019 ($P < 0.001$). Significant difference was between 2019 and subsequent years 2020, 2021 and 2022. Highest mean TD value was found in 2019, followed by 2022 and 2021. Year-wise comparison showed a significant difference between 2019–20, 2019–21 and 2019–22. Besides, a significant difference was observed in the TD values between 2020–2022 and 2021–2022. In 2019, the mean WBC/mL was 0.14 million and was the lowest. *Post hoc* analysis revealed a significant difference between 2019 and subsequent years ($P < 0.001$).

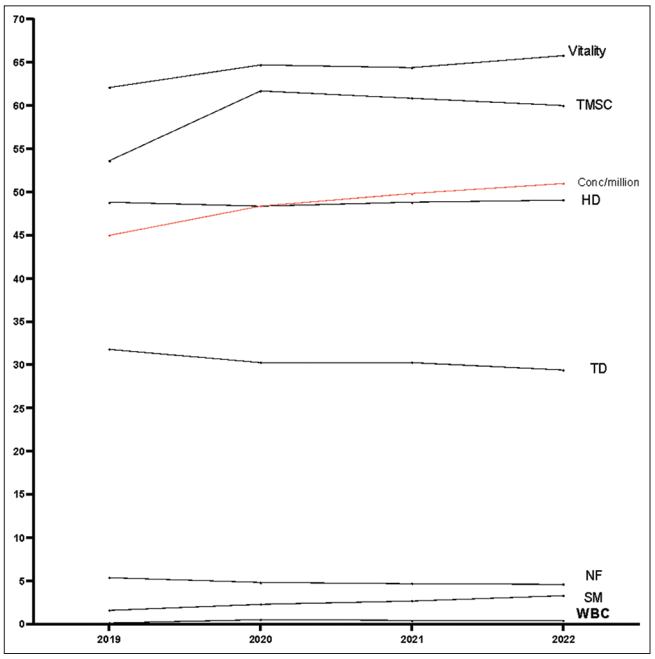
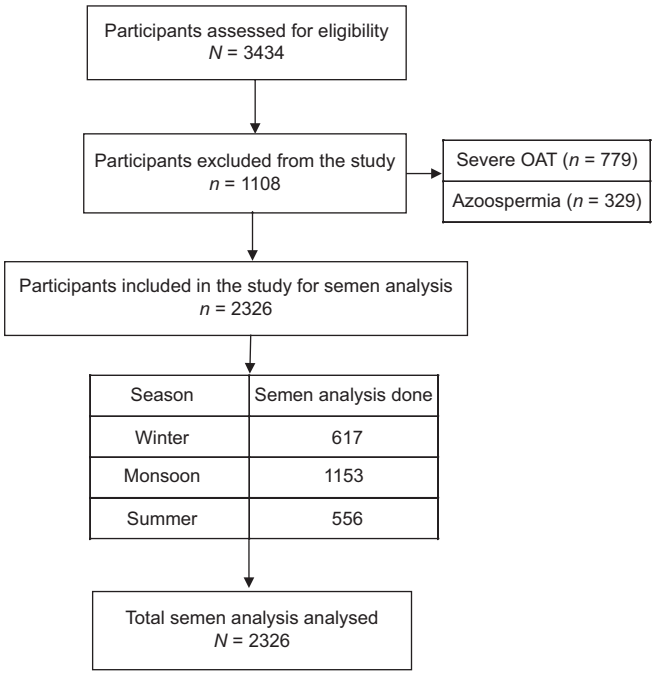


Figure 2: Line Diagram depicting year-wise changes in semen parameters. TMSC = Total motile sperm concentration, HD = Head defects, TD = Tail defects, NF = Normal forms, SM = Sluggishly motile

Discussion

We investigated, the seasonal variations in various semen parameters in a tropical climate like ours. To our knowledge, this is the first such study in India.

SC, TC, TM, TMSC and vitality showed a decline during summer, though the values did not reach statistical significance [Table 1]. This was similar to many studies published earlier.[4,7,9] AM showed no seasonal variation, but SM was significantly increased in rainy season. TM and NM showed no variation. In rainy season, HD was significantly reduced, but TD was increased [Figure 1]. In the study by Chen *et al*.,[4] in 2004, higher SC, motility and per cent normal morphology were found in spring and low in summer. Mean SC in the



Flowchart 1: Participant flowchart

spring (137.2 million/mL) was significantly higher than in the winter (99.2 million/mL), summer (93.1 million/mL) and fall (90.6 million/mL) ($P < 0.05$). Mean sperm motility was higher in the spring (52.3%) than in the summer (47.7%), fall (47.1%) and winter (44.3%). Motility in spring compared to winter was significant ($P = 0.06$). AM sperms showed no significant seasonal variation in our study, though SM sperms were highest in rainy season, reaching statistical significance [Table 1]. Chen *et al*.[4] observed highest mean normal morphology per cent in spring (7.5%) than in summer (6.7%), fall (7.0%) or winter (6.4%), but our study did not show any seasonal variation in NF per cent.

SC showed no seasonal effect in the study by Ozelci *et al*.,[3] similar to our study. However, the total sperm motility in normozoospermic men was found to be highest in fall compared to winter values ($P = 0.026$). The values were more than that in summer, though not statistically significant. The increased motility seen in fall was subsequent to an increase in the SM sperms. AM sperms were found to be highest during spring and winter. The normal morphology per cent was found to be highest in winter compared to summer specimens.

A study by Rao *et al*.,[9] for the evaluation of semen quality in university students in Wuhan including 1808 subjects, showed that semen concentration (53.2 million) and total sperm count (157.8 million) in spring were much higher than in other seasons, lowest in summer (48.8; 139.0, respectively) $P < 0.001$. In the study by Proctor *et al*.,[10] where they studied the seasonal effect on semen parameters and pregnancy in patients undergoing intra-uterine insemination, SV and concentration were not altered by seasonal conditions; quite similar to our findings, but significant seasonal differences in sperm motility were detected. Straight line velocity alone in terms of motility was significantly higher in summer months compared with winter ($P < 0.001$). Morphology was affected by season, more NFs detected in winter compared to summer ($P = 0.001$). Another study from Wuhan by Wang *et al*.[11] found exposure to ambient temperatures above threshold, caused decrease in the percentage of normal sperm morphology, the effect augmented by environment pollution. Although our study showed no change in NF, HD was significantly higher during summer and winter [Table 1]. Saint Pol *et al*.,[7] in his study to find circannual rhythms of semen parameters, found a statistically significant seasonal variation in sperm count, the highest values being recorded in late winter and early spring and the lowest values recorded in late summer. The Danish study by Gyllenborg *et al*.,[12] in 1927 subjects, also had similar findings. They found significant variation between seasons regarding SC ($P < 0.0001$) and total sperm count ($P < 0.0001$). Highest mean concentration of sperms was found in spring (77.6 million/mL) and lowest in summer (57.5 million/mL). No other semen parameter varied with season.

A retrospective review by Chen *et al*. in 2003[13] also found seasonal variations in SC and morphology, with higher SC s in winter than in fall, and a greater percentage of sperm with normal morphology in winter than in spring and summer. SC was significantly higher in winter (mean 157.9 million/mL) compared to fall (mean 119.1 million/mL) ($P < 0.05$). They found higher HDs in summer and fall. HD per cent was higher in summer in our study also. The mean percentage of sperm with normal morphology was significantly higher in winter (9.2%) than in summer and spring (7.0% and 7.5%, respectively ($P < 0.05$). SV, SC, TC, motility, TMSC and morphology diminished as age increased. The study by the same group in 2004, showed increased SC and motility in spring compared to other seasons. Centola and Eberly[14] in their analysis of 2065 semen samples, however, found no seasonal variations in terms of volume, sperm count, motility and motile count, very similar to our study. However, they found that the percentage of sperms with rapid progressive straight line velocity was significantly lower in spring. As age increased, sperm count, motility and rapid motile sperms decreased. TDs increased. However, another large study analysing 5131 samples over a 6-year period was conducted in Northern Italy by Daniele Santi *et al*.,[15]

assessing the effects of temperature and air pollution on semen parameters. Total sperm number was lower in summer/autumn (P <0.001) and was inversely related with daylight duration (P <0.001), confirming a seasonal change in semen parameters. Non-progressive motility and morphology also showed a statistically significant negative correlation with temperature.

Seasonal variations in semen parameters could have an impact in the assessment and management of male-related infertility. Politoff *et al*.[1] suggested that in oligospermia, seasonal fluctuation in sperm density should be taken into account during *vitro* fertilisation and in homologous artificial insemination. Ozelci *et al*.[3] in their Turkish study commented that both normozoospermic and oligozoospermic semen samples appeared to have better sperm parameters in spring and winter, and the circannual variation of semen parameters may be important in diagnosis and treatment decisions. Centola and Eberly study[14] found significant seasonal variations in sperm motility and suggested such variations could be clinically relevant and to be considered when designing experimental protocols. Similar suggestion was given by Santi *et al*.[15] that seasonal and environmental associations should be considered when assessing male infertility-related parameters. Our study showed an increasing trend in semen concentration in winter, compared to summer, significantly lower head and TDs in cooler climates and will need to be considered in fertility management of oligospermic men.

Although not our primary objective, we did an year-wise analysis from 2019 to 2022, which showed a progressive increase in SC, SM sperm per cent and vitality, along with a decrease in NFs subsequent to significant increase in HDs and MD, which raises suspicion regarding a link to COVID infection and quarantine, which was rampant in the state during the study period. However, since the data regarding COVID infection were not collected, an association could not be made.

We are a referral centre catering to a large number of patients from over five districts. Hence, we had a good sample size representing a cross-section of the state community. There were no studies on seasonal variations conducted in India to our knowledge. There was minimal inter-observer variability as the analysis was done in a single well-equipped andrology laboratory with two trained technicians.

However, our study had few limitations. Seasonal variations in normal and suboptimal specimens were not analysed separately, though we had excluded severe azoospermia. Confounding factors such as smoking, obesity and lifestyle diseases were not recorded. Only one sample per person was collected, there may be within person variability in semen parameters. Using a single sample to characterize an individual may introduce error, likely random error.

Conclusion

Our study showed an increasing trend in semen concentration in winter, compared to summer, significantly lower HD and TDs in cooler climates, suggesting seasonal influence on semen parameters. The absence of statistically significant seasonal variation in SC might be because we do not experience very wide ranges or extremes of temperature. It is possible that a similar study replicated in regions where temperature extremes are experienced, might show significant seasonal variations in semen parameters. Seasonal variations if present may need to be considered in the management of infertile patients, especially if the male is oligospermic.

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Conflicts of interest

There are no conflicts of interest.

Data availability statement

The data of the study are available at request from the corresponding author Dr. Anitha M.

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