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Study on Semen Quality among Men Seeking Infertility Treatment in Tamale, Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. This study was designed and supervised by authors SBB and PPMD. Authors RA and MB drafted the manuscript. Authors YA and CN contributed to the draft of the manuscript. Authors RA, MB and KM made contributions to the study design and also helped draft the manuscript. Authors KM, SKA and FB participated in the recruitment and sampling of study subjects. Authors RA, HO, GA and SD made financial contributions towards the study and were involved in the laboratory analysis of the samples. Authors SBB and PPMD supervised and made intellectual contributions to the manuscript. Author RA participated in subject recruitment. Authors PPMD, YA and FB were involved with the statistical analysis. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Standard semen analysis is the surrogate measure of male fertility in clinical practice. According to recent studies, there is a slight increase in percentage of couples who are facing infertility problems globally. This study determined the semen quality trends of men seeking infertility treatment in the Tamale Metropolis, Ghana.

Methods: This is a retrospective cross-sectional study with data from archival records over a period of six years; from January 2015 to December 2020.

Results: A total of 785 semen analysis reports of men seeking infertility treatment over a period of 6 years were considered. In all, 187 (23.82%) had normozoospermia, 347 (44.20%) had oligozoospermia, and 251 (31.97%) had azoospermia. Out of the 785 subjects, 344 (57.91%) had abnormal semen parameters even though their semen volume was normal. Percentage abnormal motility, morphology and viability rose sturdily from 5.74%, 8.14%, and 12.59 in 2015 through 20.87%, 18.77%, 19.85% in 2017 to 26.85%, 27.95 and 21.55 respectively in 2020. Abnormal pH and volume also rose from 8% and 8.59 in 2015 to 23.69 and 24.91 respectively in 2020.

The highest variances were seen in the age group 31-40 years ($p<0.0001$). Males with hypospermia were 56% less likely to have abnormal sperm concentration than those with hyperspermia (OR=0.44; 95% CI=0.23–0.83; p=0.012).

Conclusion: This study shows a high rate of abnormal semen quality of male partners of infertile couples. The trend of oligozoospermia increased during the past six years while the trend of normozoospermia remain fairly constant. Oligoasthenoteratozoospermia has increased consistently from 2015 to 2020, buttressing the fact that, male infertility is on the ascendancy.

Keywords: Infertility; semen quality; oligozoospermia; azoospermia; morphology; motility; sperm count.

1. INTRODUCTION

Male infertility is known to contribute to about half of all infertility cases. According to recent studies by the WHO, approximately 8-10% of couples are facing some kind of infertility problem. Semen quality is a significant factor which reflects male reproductive health. According to Jensen, Carlsen [1], low semen quality may be a potential contributing factor in reducing fertility rates and the use of assisted reproductive technology (ART) may improve the number of children born to such individuals. Meta-analysis show that there has been a 57% reduction in sperm concentration around the globe over the past 35 years, a 32.5% decline over the past 50 years in Europe, and a 72.6% decline found in Africa over the past 50 years [2].

In Ghana, studies have shown that the prevalence of male infertility is higher than females [3]. Base on the literature reviewed, there is a gap in knowledge on semen quality trends; the prevalence of normospermia (normal semen quality), the relationship between semen volume and other semen quality parameters in the Tamale metropolis. Increasing male age is associated with increased time to conception. This reflects the age-related increase in acquired medical conditions, decreases in semen quality, and increasing rates of DNA fragmentation seen in sperm. Also, there is an association between the age of the male partner and the incidence of birth defects and chromosomal abnormalities [4]. Therefore, this study aims to determine the semen quality trends men seeking infertility treatment in the Tamale Metropolis.

1.1 Study Area and Setting

The study was conducted in the Tamale Metropolis of the Northern region of Ghana. The Metropolis has five (5) hospitals, nine (9) health centers, and twenty-eight CHPS. Out of the five hospitals, one is a Teaching Hospital serving as a referral hospital for the Northern part of Ghana GSS [5]. The study employed a retrospective cross-sectional study design.

2. DATA COLLECTION METHODS

Secondary data spanning the period of 2015 to 2020 were collected. Semen quality data was sourced from the databases of Tamale Teaching Hospital into a Microsoft Excel document-based on the variables of the study indicated in the structured extraction sheet. The extraction sheet consisted of variables such as year, age, and all semen parameters.

2.1 Data Management and Analysis

STATA version 16.0 statistical software and Microsoft Excel 2019 was used for data analysis. Frequencies and percentages were calculated for categorical data. Means and standard deviations were calculated for normally distributed continuous data. Trends in semen parameters over the study years were assessed using Microsoft Excel 2019. Independent t-test was used to analyze continuous variables and presented as tabulated means and standard deviations. Linear and multiple regression models were used to examine the relationship between age with each semen parameter while potential confounding factor were controlled. All statistical tests with p values < 0.05 were interpreted as statistically significant. Results were presented in Tables 1–6 and Figs. 1–3.

3. RESULTS

3.1 Distribution of Semen Parameters Across the Study Duration

Table 1 depicts the distribution of semen analysis outcomes from 2015 to 2020 in the Tamale Metropolis. Of a total of 785 semen analysis report of men seeking infertility treatment analysed over a period of 6 years, 187 (23.82%) had normozoospermia (normal semen quality), 347 (44.20%) had oligozoospermia (low sperm concentration), and 251 (31.97%) had azoospermia (absence of sperms in semen).

3.2 Yearly Semen Quality Trends

Fig. 1 shows a rise in the percentage of oligozoospermia cases over the 5 years period; thus, 35.50% in 2016, 40.60% in 2017, 47.43% in 2018, 53.63% in 2020. There was a decline in azoospermia cases from 38.27% in 2015 to 15.94 in 2020.

3.3 Comparison of Semen Parameters between Normozoospermia and Oligozoospermia

Table 1 compares semen parameters such as sperm concentration, volume, viability, pus cell, motility, morphology, and pH among subjects with oligozoospermia and normospermia. Subjects with normospermia had significantly higher percentage of sperm cells with normal morphology ((99.15±46.29%) compared with subjects with oligospermia (72.02±14.31%) (p = 0.014). Viability was higher in the normospermia group (78.60±29.24) compared with the oligozoospermia group (57.63±38.77) (p = 0.023) (Table 2).

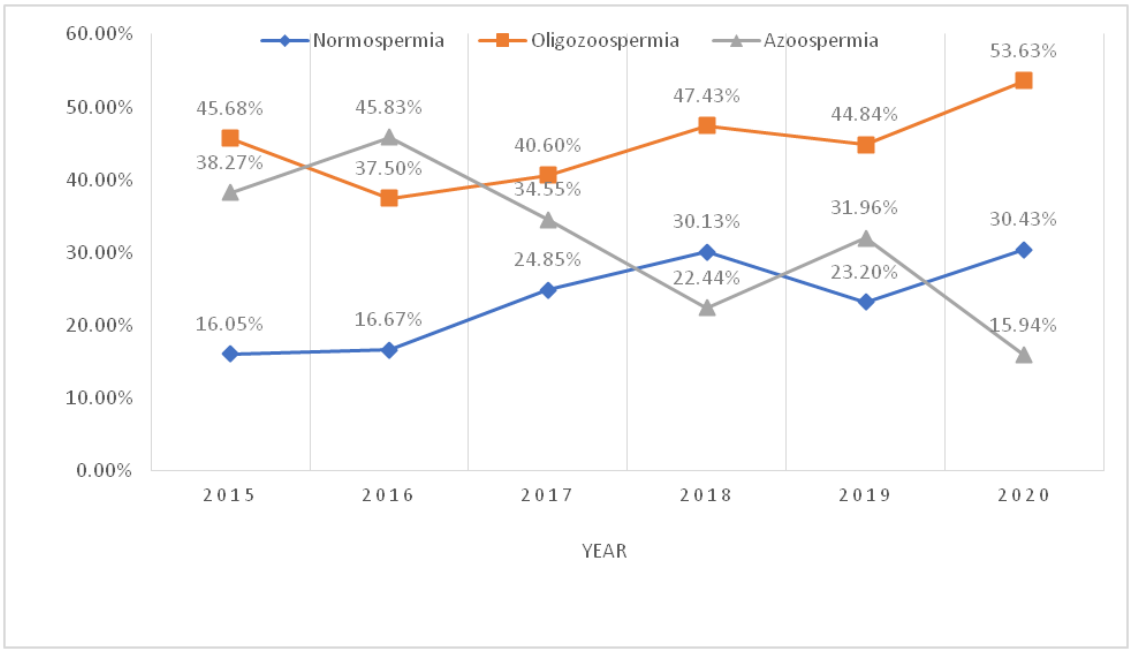

Fig. 1. Year trend of sperm concentration in the last six years (2015-2020)

Table 1. Comparison of semen parameters between normozoospermia and oligozoospermia

Category	Normozoospermia	Oligozoospermia	p-value
Volume	2.72±1.06	2.56±1.13	0.177
Viability	78.60±29.24	57.63±38.77	0.023
Pus cells	7.69±6.51	7.47±4.18	0.691
MOT	82.04±41.46	68.01±33.60	0.151
MOP	99.15±46.29	72.02±14.31	0.014
pH	8.08±0.44	8.11±0.50	0.616

**p<0.05 is considered significant; MOT = Motility; MOP = Morphology*

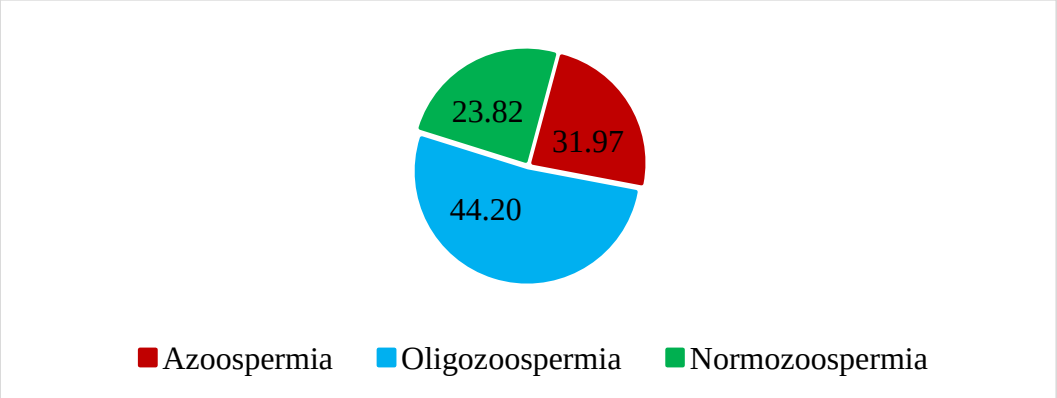

Fig. 2. Percentage distribution of sperm concentration among participants

Table 2. Relationship between age group and semen findings among males

variable	Semen findings			χ^2; (diff); p-value
	Azoospermia n (%)	Oligozoospermia n (%)	Normozoospermia n (%)	
Age group (year)				26.71; (4), 0.000 *
21-30	48 (25.81)	101 (24.88)	80 (42.11)	
31-40	80 (43.01)	194 (47.78)	82 (43.16)	
>40	58 (31.18)	111 (27.34)	28 (14.74)	
Total	186 (100.00)	406 (100.00)	190 (100.00)	

** Statistically significant at p<0.05; diff: Difference; χ^2: Chi-square value*

3.4 Percentage of Males with Azoospermia, Oligozoospermia and Normozoospermia

Using WHO standard for semen normality (Butt & Akram, 2013b), a total of 187 subjects (23.82%) had normozoospermia (spermatozoa concentrations greater than 20 million per milliliter), 347 (44.20%) had oligozoospermia (spermatozoa concentration less than 20 million per milliliter), and 251 (31.97%) had no spermatozoa in the sediment of the ejaculate after centrifugation.

3.5 Relationship between Age Group and Semen Concentration

Table 2 compares semen analysis outcomes according to age groups. The mean age of the study subjects was 35.29±7.98. Only 14.74% of subjects >40years had normal semen quality. The percentages of azoospermia and oligozoospermia were highest at 43.01% and 47.78% respectively between the ages of 31 to 40 years but are low at 25.81% and 24.88% respectively between the ages of 21 to 30 years. These differences were statistically significant (χ^2=26.71, (diff=4), p<0.0001).

3.6 Univariate Logistic Regression Analysis of Age Group and Abnormal Semen Quality

Logistic regression analysis was conducted to ascertain the strength of association between age and abnormal semen quality. Results of the binary logistic regression indicated that, males

within 31- 40 years were significantly 2 times more likely to have abnormal semen quality as compared to those within 21-30 years (OR = 1.79; 95% CI = 1.24 – 2.59; p = 0.002). Similarly, males above 40 years of age were significantly 3 times more likely to have abnormal semen quality as compared to those within 21-30 years (OR= 3.24; 95% CI = 2.00 – 5.26; p < 0.0001) (Table 3).

3.7 Relationship between Semen volume Abnormal Sperm Concentration

Semen volume was categorized into hypospermia (<2ml), normospermia (2-5ml) and hyperspermia (>5ml). The majority of the subjects (58.22%) were normospermic, while only 41.78% had abnormal semen volume; this comprised 35.41% with hypospermia and 6.37% with hyperspermia (Table 4).

3.8 Association between Semen Volume and Abnormal Sperm Concentration

Pearson chi-squarere test analysis was conducted to establish the relationship between semen volume and abnormal sperm concentration (Table 5). The highest abnormal sperm concentration 344 (57.91%) was seen in normal semen volume (normospermia), followed by hypospermia 219 (36.87%). The bivariate analysis showed that, there was a statistically significant association between semen volume and sperm concentration (normal, and abnormal) (χ^2=6.57, (diff=2), p=0.037).

3.9 Univariate Logistic Regression Analysis of Semen Volume and Abnormal Sperm Concentration

To determine the strengths of association between semen volume and abnormal sperm concentration, logistic regression analysis was performed. The binary logistic regression revealed that significantly, hypospermia was found in males with 56% less chance than those with hyperspermia to have abnormal sperm concentration (OR=0.44; 95% CI=0.23–0.83; p=0.012) (Table 6).

3.10 Trend of Abnormal Semen Parameters

Percentage abnormal motility, morphology and viability rose sturdily from 5.74%, 8.14%, and 12.59 in 2015, through 20.87%, 18.77%, 19.85% in 2017 to 26.85%, 27.95 and 21.55 respectively in 2020. Abnormal pH and volume also rose from 8% and 8.59 in 2015 to 23.69 and 24.91 respectively in 2020 (Fig. 3).

Table 3. Univariate logistic regression analysis of age group and abnormal semen quality

Variable	Abnormal semen quality		
	Odds Ratio	95% Confidence Interval	p-value
Age group (years)			
21-30	1		
31-40	1.79	1.24 – 2.59	0.002 *
>40	3.24	2.00 – 5.26	0.000 *

** Statistically significant at p<0.05*

Table 4. Distribution of semen volume

Volume	Frequency (N=785)	Percentages (%)
Normospermia (2-5mls)	457	58.22
Hypospermia (<2 mls)	278	35.41
Hyperspermia (>5 mls)	50	6.37

Table 5. Association between semen volume and abnormal sperm concentration

Variable	Sperm concentration		X^2; (diff); p-value
	Normal n (%)	Abnormal n (%)	
Semen volume			
Normospermia (2-5ml)	113 (59.16)	344 (57.91)	
Hypospermia (<2 ml)	59 (30.89)	219 (36.87)	6.57; (2); 0.037*
Hyperspermia (>5 ml)	19 (9.95)	31 (5.22)	

** Statistically significant at p<0.05; diff: Difference; X^2: Chi-square value*

Table 6. Univariate Logistic Regression analysis of semen volume and abnormal sperm concentration

Variable	Abnormal sperm concentration		
	Odds Ratio	95% Confidence Interval	p-value
Semen volume			
Normospermia (2-5ml)	0.82	0.57 – 1.17	0.277
Hypospermia (<2 ml)	1		
Hyperspermia (>5 ml)	0.44	0.23 – 0.83	0.012*

** Statistically significant at p<0.05*

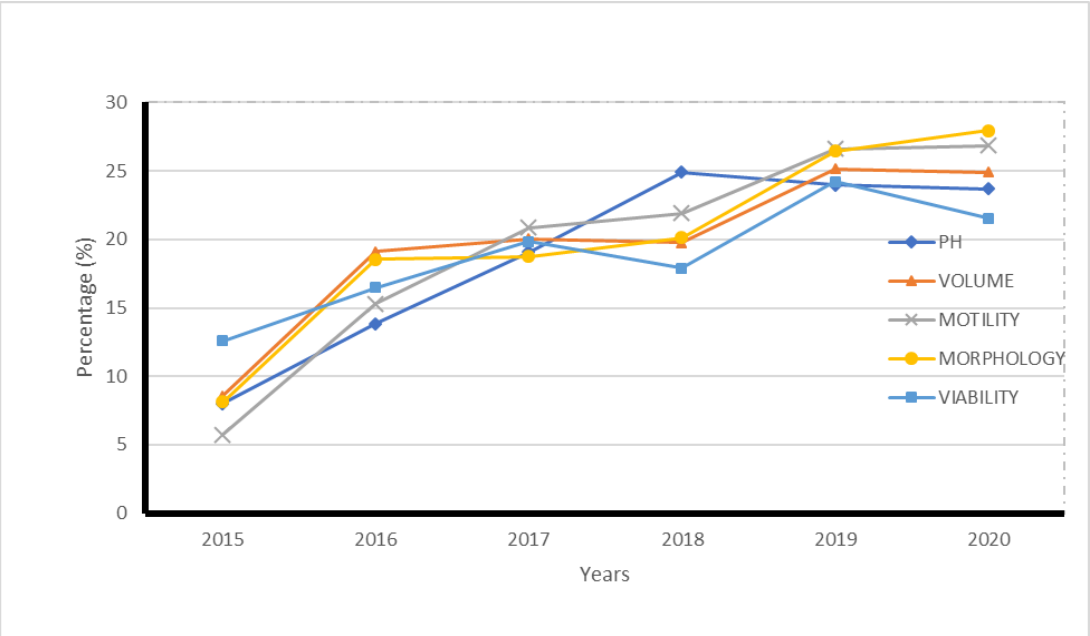

Fig. 3. Percentage frequencies of abnormal semen parameters

4. DISCUSSION

Infertility has been a subject of debate and the female partners have always had to bear the brunt of the sociocultural connotations of this multifaceted issue [6]. Advancements and progress made in novel assisted reproductive techniques established males to be equal, if not higher contributors to this complex problem [7]. Despite education and enlightenment, the social attitude towards infertility results in much trauma, emotional instability and psychological stress, which in turn has an adverse bearing on the physiology of the individual, particularly in the northern Ghana social set-up, where there has been strong emphasis on child-bearing [8]. This study determined the semen quality trends in males seeking infertility treatment in Tamale from 2015 to 2020.

Semen analysis provides some insight into the pathology of the male genital tract [8,9]. Being a hospital base study, the findings of this study should be carefully applied to the general population. Earlier studies in Ghana revealed that, the prevalence of male infertility is 15.8% and 11.8 in females [3]. Similar studies conducted by Samal, Dhadwe [10] reported the incidence of male infertility as 62%, and 38% at Abakaliki in south eastern Nigeria by Ugwuja, Ugwu [11]. Blay, Pinamang [3] concluded that, a good semen quality increases the probability of conception and the male factor is responsible for infertility about 90% of the time.

This study shows declining semen quality in Tamale for the last six years. Semen volume is significantly associated with sperm concentration (Tables 4, 5 and 6). In this study, majority of the subjects had normospermia, followed by hypospermia, and few of the participants present with hyperspermia. Reduced ejaculated volume can reflect abnormalities in accessory sex gland's fluid synthesis ability [12]. It can also be

indicative of a physical obstruction in the reproductive tract or in cases of incomplete retrograde ejaculation. In this study, mean ejaculate volume in normospermics was significantly higher than the mean ejaculate volume in oligozoospermia samples (Table 6). Subjects with hypospermia are significantly less likely to have abnormal sperm concentration than subjects with hyperspermia. This is because, hyperspermia led to a dilution of the sperm concentration, leading to lower sperm count in the hyperspermia group. The result is comparable to a study conducted in Sudan where majority of the subjects (89.7%) had normal semen volume, only 10.3% had abnormal semen volume [13]. The present study results are comparable with a study conducted in Nigeria in which majority of the subjects (91%) had normal semen volume, only 9% had abnormal semen volume i.e 7.3% hypospermia and 1.7% hyperspermia [14]. The observed hypospermia may be related to insufficiency of the bulbourethral glands, seminal vesicles, vas-deference, seminiferous tubules in the testicles, epididymis and the prostate glands because these organs secret seminal plasma [15]. This result suggest that seminal fluid volume plays an important role in the etiology of male infertility.

Oligozoospermia is on the rise among subjects, especially among subjects above 31 years, but lower in subjects 30 years and below (Table 3). The result of the present study reveals that, a higher percentage of participants had oligozoospermia compared with participants with azoospermia (Fig. 2, Table 2). This observation may be attributable to a myriad of causes including a decline in testosterone and testicular function, leading to a depression in spermatogenesis. In their study, Nsonwu-Anyanwu, Ekong [16] observed a reduction in the antioxidation capabilities of Vitamin E and Glutathione, whose concentrations are lower in the blood of azoospermic and oligozoospermic participants. This leads to higher oxidative stress amongst infertile participants, resulting in damage to spermatozoa by reactive oxygen species [17], resulting in oligospermia.

Various semen quality disorders responsible for infertility such as oligospermia and azoospermia recorded in this study are major contributory factors to infertility in Ghana, and are in agreement with earlier studies in Ghana by Gyasi-Sarpong, Maison [18], Ikechebelu, Adinma [19], Nwafia, Igweh [14], Ugwuja, Ugwu [11] in Nigeria. These factors may be responsible for the poor semen analysis outcomes obtained by the use of conventional infertility treatment methods [3,18]. In many studies, the reported incidence of azoospermia ranges between 12.32% to 16% [8-10,20] and oligospermia approximately 33% [8,10,20,21] which are lower compared to the findings of this study. The higher prevalence of oligospermia and azoospermia identified in this study compared to earlier studies could be attributable to the fact that this study is a hospital base study conducted amongst participants seeking treatment for infertility. They may already be known to have one deleterious semen disfunction for which they seek treatment.

In addition, this study revealed that the overall trend in semen quality declined throughout the study period. Cumulatively, the frequencies of abnormalities detected in semen pH, volume, motility, morphology and viability increased sturdily during the study period. Lower semen pH coupled with lower semen volume may indicate an impairment to the release of seminal plasma as a result of an obstruction. Higher seminal plasma pH can to attributed to infections of the reproductive system. Laboratory turn-around time also greatly impacts semen pH, such that after ejaculation, semen pH increases with delays in sample analysis. Abnormal pH reduces the sperm's ability to fertilize an ovum.

The result of this study shows that, oligozoospermia and azoospermia have the highest frequency among the age group 31–40 years and above. There is statistically significant association between advanced male age (31–40 years and above) and abnormal semen quality (Table 3). This study findings are congruent with several earlierstudies [22-24]. A retrospective study conducted among 933 male partners of women attending the fertility clinic in Chandigarh, India by Baliyan *et al*. (2017) and in Nigeria by Owolabi, Fasubaa [25] all reported an age-related decline in semen quality.

One plausible explanation for these results could be as a result of an age-related increase in reproductive tract oxidative stress and/or increased testicular germ cell death as older men may generate more sperms with DNA damages [4,15,26]. Oxidative stress within the testis and reproductive tract can damage sperm DNA, as well as, the sperm mitochondrial and nuclear membranes [22]. Germ cell apoptosis during

spermatogenesis is a normal event, however, this process may be less effective in older men resulting in the release of more DNA-damaged sperm [10, 20]. Indeed, older male testes may have lower apoptotic frequencies than young adult's testes [27]. While apoptosis has been discovered in the testes of older men, no studies have been conducted to compare the rates of germ cell death in men of various ages [28]. Studies also show that there is a 1.6% decrease in serum testosterone levels with age, with free and bioavailable levels reduce by 2-3% [29]. Testosterone plays a major role in semen production and maturation, hence, increase in age may lead to increase in abnormal semen quality [29].

Good sperm motility is a requisite for normal fertilization. Spermatozoa travel a long distance to meet and fertilize the oocyte, so motility comes with sperm maturation in their passage through the epididymis. The process of epididymal sperm maturation occurs under the influence of epididymal proteins and other substances which produce structural and biochemical changes in the sperms. Thus, motility is chiefly a parameter of male infertility and the reason for intracytoplasmic injection [25]. Prostatic changes, including smooth muscle atrophy, may affect sperm motility [30,31].

The mean percentage of normal motile sperms is higher in normospermic samples as compared with oligozoospermic samples (Table 2). Although advancing techniques had somewhat overcome the problems of sperm motility in infertile couples, asthenozoospermia is still a common cause of human male infertility [25]. Sperm motility may be changing, as pertains to other sperm parameters and their relative levels may depend on the existing semen quality in the individual [32]. Declining sperm motility could also be due to age-related transformations in accessory sex gland and epididymal function [33,34].

5. CONCLUSION AND RECOMMENDATIONS

Semen pH, sperm motility, morphology, viability and concentration may be the most informative semen parameters used as measurement of infertility in Men. These parameters declined in this study over the study period as the frequency of abnormalities in these parameters increased over the study period.

5.1 Recommendations

1. There is the need for the incorporation of semen analysis into the national health insurance scheme for easy access and treatment of infertility in male partners.
2. Further studies are necessary to elucidate and classify role played by the various causes of male factor infertility such as varicocele, testicular infection (parasitic or viral), endocrine disorders, and disturbances of hypothalamic-pituitary-testicular axis.
3. There is an urgent need for advocacy for men to accept responsibility for their contribution to infertility and to reduce stigmatizing and ostracizing women for infertility.
4. There is also the need for advocacy for men to marry early if they desire raising children of their own.

6. LIMITATIONS

The limitation of this study is that, a large number of the subjects have incomplete records and hence could not be included in the study.

CONSENT

Consent was sought from each participant before being included in the study. Consent form was given to each participant to sign or thumb-print and confidentiality was assured. Subjects who did not give their consent were excluded from the study. A copy of the written consent is available for review by the Editorial office of your journal.

ETHICAL APPROVAL

Ethical clearance was given by the committee for human publication and research ethics of the University for Development Studies. All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the current October, 2013 amended Declaration of Helsinki

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jensen TK, et al. Poor semen quality may contribute to recent decline in fertility rates. Hum Reprod. 2002;17(6):1437-40.
2. Sengupta P, Nwagha U, Dutta S, Krajewska-Kulak E, Izuka E. Evidence for decreasing sperm count in African population from 1965 to 2015. Afr Health Sci. 2017;17(2):418-27. DOI: 10.4314/ahs.v17i2.16, PMID 29062337.
3. Blay RM, Pinamang AD, Sagoe AE, Owusu EDA, Koney NK, Arko-Boham B. Influence of lifestyle and environmental factors on semen quality in Ghanaian men. Int J Reprod Med. 2020;2020:6908458. DOI: 10.1155/2020/6908458, PMID 33150165.
4. Dain L, Auslander R, Dirnfeld M. The effect of paternal age on assisted reproduction outcome. Fertil Steril. 2011;95(1):1-8. DOI: 10.1016/j.fertnstert.2010.08.029, PMID 20932518.
5. GSS, demographic and health survey report; 2007.
6. Milardi D, Grande G, Sacchini D, Astorri AL, Pompa G, Giampietro A, et al. Male fertility and reduction in semen parameters: A single tertiary-care center experience. Int J Endocrinol. 2012;2012:649149. DOI: 10.1155/2012/649149, PMID 22319527.
7. Li WN, Jia MM, Peng YQ, Ding R, Fan LQ, Liu G. Semen quality pattern and age threshold: A retrospective cross-sectional study of 71,623 infertile men in China, between 2011 and 2017. Reprod Biol Endocrinol. 2019;17(1):107. DOI: 10.1186/s12958-019-0551-2, PMID 31815629.
8. Butt F, Akram N. Semen analysis parameters: Experiences and insight into male infertility at a tertiary care hospital in Punjab. J Pak Med Assoc. 2013;63(5):558-62. PMID 23757979.
9. Rikhasor RM, et al. Semen analysis of infertile men and plasma levels of LH, FSH, and testosterone in oligospermia. Med Channel. 2001;7(2):30-2.
10. Samal S, et al. Epidemiological study of male infertility. Indian Med Gaz. 2012;5: 174-80.
11. Ugwuja EI, Ugwu NC, Ejikeme BN. Prevalence of low sperm count and abnormal semen parameters in male partners of women consulting at infertility clinic in Abakaliki, Nigeria. Afr J Reprod Health. 2008;12(1):67-73. PMID 20695157.
12. Corona G, Jannini EA, Vignozzi L, Rastrelli G, Maggi M. The hormonal control of ejaculation. Nat Rev Urol. 2012;9(9): 508-19. DOI: 10.1038/nrurol.2012.147, PMID 22869001.
13. Ahmed M, et al. Semen analysis of infertile Sudanese males in Gezira state central Sudan. Sudanese J Public Health. 2009;4(3):340-4.
14. Nwafia WC, Igweh JC, Udebuani IN. Semen analysis of infertile Igbo males in Enugu, Eastern Nigeria. Niger J Physiol Sci. 2006;21(1-2):(67-70). DOI: 10.4314/njps.v21i1-2.54254, PMID 17242721.
15. Frydman R, Grynberg M. Introduction: male fertility preservation: innovations and questions. Fertil Steril. 2016;105(2): 247-8. DOI: 10.1016/j.fertnstert.2015.12.012, PMID 26746134.
16. Chinyere Nsonwu-Anyanwu AC, Raymond Ekong E, Jeremiah Offor S, Francis Awusha O, Chukwuma Orji O, Idiongo Umoh E, et al. Heavy metals, biomarkers of oxidative stress and changes in sperm function: A case-control study. Int J Reprod Biomed. 2019;17(3):163-74. DOI: 10.18502/ijrm.v17i3.4515, PMID 31435598.
17. Bhardwaj A, Verma A, Majumdar S, Khanduja KL. Status of vitamin E and reduced glutathione in semen of oligozoospermic and azoospermic patients. Asian J Androl. 2000;2(3):225-8. PMID 11225982.
18. Gyasi-Sarpong CK, Maison POM, Koranteng AK. The pattern of male infertility in Kumasi, Ghana. Afr J Infertil Assist Conception. 2017;2(1):3.
19. Ikechebelu JI, Adinma JI, Orie EF, Ikegwuonu SO. High prevalence of male infertility in southeastern Nigeria. J Obstet Gynaecol. 2003;23(6):657-9.

DOI: 10.1080/01443610310001604475, PMID 14617473.

20. Kumar N, Choudhari AR, Singh AK. Prevalence of male factor infertility in last ten years at a rural tertiary care centre of central India: A retrospective analysis. Indian Journal of Obstetrics and Gynaecology Research. 2015;2(3):132-6.
21. Jequier AM. Semen analysis: A new manual and its application to the understanding of semen and its pathology. Asian J Androl. 2010;12(1):11-3.
DOI: 10.1038/aja.2009.12, PMID 20111075.
22. Das M, Al-Hathal N, San-Gabriel M, Phillips S, Kadoch IJ, Bissonnette F, et al. High prevalence of isolated sperm DNA damage in infertile men with advanced paternal age. J Assist Reprod Genet. 2013;30(6):843-8.
DOI: 10.1007/s10815-013-0015-0, PMID 23722935.
23. Urhoj SK, Jespersen LN, Nissen M, Mortensen LH, Nybo Andersen AM. Advanced paternal age and mortality of offspring under 5 years of age: A register-based cohort study. Hum Reprod. 2014;29(2):343-50.
DOI: 10.1093/humrep/det399, PMID 24316515.
24. Oliveira JBA, Petersen CG, Mauri AL, Vagnini LD, Baruffi RLR, Franco JG. The effects of age on sperm quality: an evaluation of 1,500 semen samples. JBRA Assist Reprod. 2014;18(2):34-41.
DOI: 10.5935/1518-0557.20140002, PMID 35761724.
25. Owolabi AT, Fasubaa OB, Ogunniyi SO. Semen quality of male partners of infertile couples in Ile-Ife, Nigeria. Niger J Clin Pract. 2013;16(1):37-40.
DOI: 10.4103/1119-3077.106729, PMID 23377467.
26. Crosnoe LE, Kim ED. Impact of age on male fertility. Curr Opin Obstet Gynecol. 2013;25(3):181-5.
DOI: 10.1097/GCO.0b013e32836024cb, PMID 23493186.
27. Lirdi LC, Stumpp T, Sasso-Cerri E, Miraglia SM. Amifostine protective effect on cisplatin-treated rat testis. The anatomical record. Anat Rec (Hoboken). 2008;291(7):797-808.
DOI: 10.1002/ar.20693, PMID 18543292.
28. Park HJ, Kim JS, Lee R, Song H. Cisplatin induces apoptosis in mouse neonatal testes organ culture. Int J Mol Sci. 2022;23(21):13360.
DOI: 10.3390/ijms232113360, PMID 36362147.
29. Stanworth RD, Jones TH. Testosterone for the aging male; current evidence and recommended practice. Clin Interv Aging. 2008;3(1):25-44.
DOI: 10.2147/cia.s190, PMID 18488876.
30. Harris ID, Fronczak C, Roth L, Meacham RB. Fertility and the aging male. Rev Urol. 2011;13(4):e184-90. PMID 22232567.
31. Leisegang K, Henkel R, Agarwal A. Obesity and metabolic syndrome associated with systemic inflammation and the impact on the male reproductive system. Am J Reprod Immunol. 2019;82(5):e13178.
DOI: 10.1111/aji.13178, PMID 31373727.
32. WHO. WHO laboratory manual for the examination of human semen and sperm–cervical mucus interactions. 1992;1-107.
33. Elzanaty S. Association between age and epididymal and accessory sex gland function and their relation to sperm motility. Arch Androl. 2007;53(3):149-56.
DOI: 10.1080/01485010701225667, PMID 17612873.
34. Henkel R, Maass G, Schuppe HC, Jung A, Schubert J, Schill WB. Molecular aspects of declining sperm motility in older men. Fertil Steril. 2005;84(5):1430-7.
DOI: 10.1016/j.fertnstert.2005.05.020, PMID 16275240.

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