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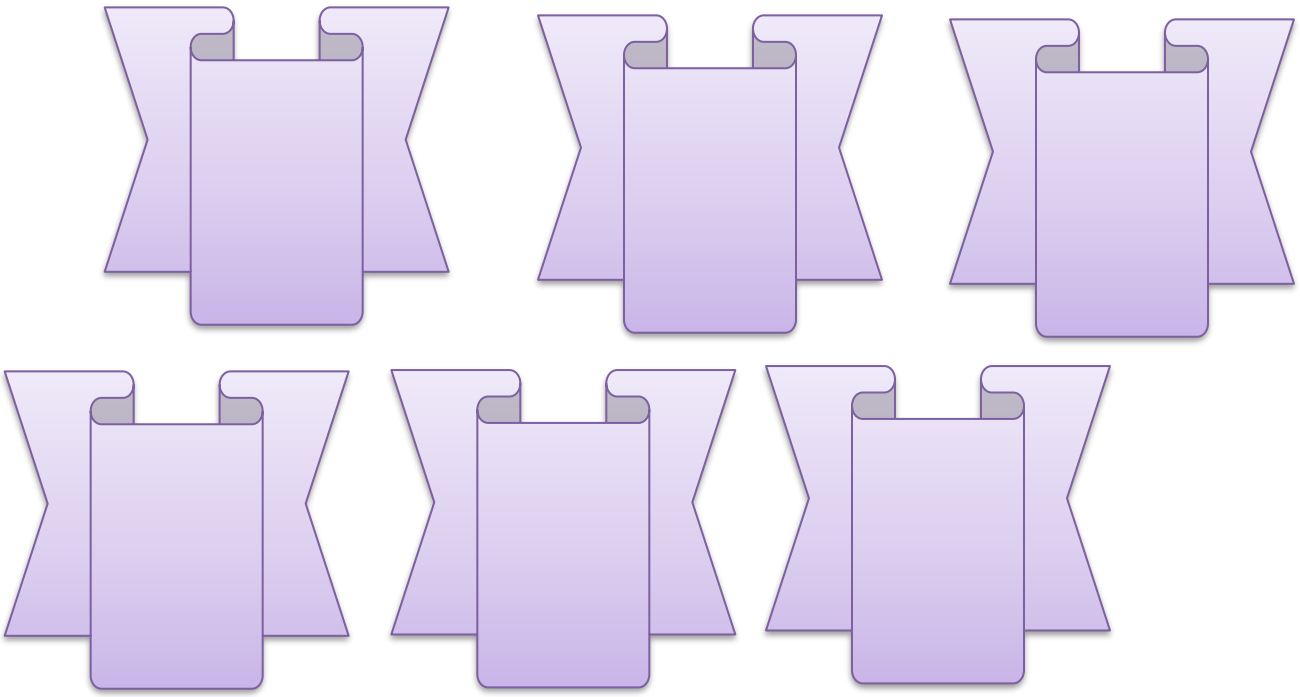

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Original Article

Evaluation of Male Accessory Gland Markers and Seminal Parameters in Obese Infertile Men

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ABSTRACT

Background: Numerous researches indicate that being overweight or obese may change how accessory glands are structured and function. As a result, it could be valuable to examine chemical markers of accessory glands as a means of identifying these changes.

Aim of the work: This study aims at evaluating the effect of obesity on markers of accessory glands [seminal vesicles and prostate], epididymis and seminal parameters [volume, concentration, motility, morphology, viability] in infertile men.

Patients and Methods: This study is a comparative cross-sectional study that included 50 males complaining from infertility, who were divided in two groups according to BMI; control group: BMI [18-25 kg/m^2] and case group: BMI ≥ 25 kg/m^2. Semen analysis and markers of accessory gland were analyzed for all patients.

Results: The semen volume, sperm count was significantly decreased in obese adults as compared to controls. The total motility, progressive motility ratio and ratio of immotile sperms all were affected among obese infertile men. Serum fructose, citric acid and alpha glucosidase levels were all affected among obese individuals with statistically significant difference [P= <0.001].

Conclusion: Obese men showed decreased sperm and prostatic function as compared with controls. Markers of oxidative stress are linked with progressive adiposity. So that, avoiding excessive body weight in infertile men at the appropriate time could lead to an improvement in both infertility and prostate disorders.

Keywords: Obesity; Infertility; Semen; Males accessory gland

INTRODUCTION

More than one-third of the world's population is affected by obesity, which is regarded as a widespread health issue [1]. Infertility is characterized as the failure to achieve pregnancy even after one year of unprotected sexual intercourse. It impacts roughly 15% of couples, which translates to about 48.5 million couples worldwide [2].

Obesity can lead to a variety of health issues, such as cardiovascular diseases, type 2 diabetes mellitus, malignancy [including prostate cancer], neurodegeneration, and accelerated aging. In men, these complications can also result in erectile dysfunction, poor semen quality, and subclinical prostatitis. The effects of obesity on the male reproductive system are not yet fully understood, but factors such as hyper-insulinemia, hyperleptinemia, oxidative stress and chronic inflammation may play a significant role [1].

Reactive oxygen species are a significant cause of sperm cell dysfunction in the testicular environment. They can cause DNA damage and compromise the cell membrane integrity of spermatozoa. It has been noted that obese men tend to have higher levels of reactive oxygen species, which can cause changes in DNA methylation in sperm. These alterations in methylation have the potential to affect embryo development and the phenotype of offspring. The connection between inflammation and oxidative stress in the testis is of particular importance in understanding the subfertility and infertility linked to being overweight or obese [3].

Individuals who are obese tend to have an excess amount of fat in their testis, which is distributed abnormally, resulting in a condition called scrotal lipomatosis. This condition is associated with infertility, and one of the primary reasons is the disruption of thermoregulation in the testis of such individuals. The excess scrotal fat acts as insulation, raising the scrotal temperature and leading to testicular germinal atrophy and spermatogenic arrest. The higher mitotic activity of germ cells is the reason behind their susceptibility to heat stress. Specifically, the elevated temperature of the testis can cause germ cell apoptosis, autophagy, DNA damage, and the generation of reactive oxygen species [3].

There are two primary ways in which oxidative stress can reduce male fertility. First, it damages the cytoplasmic membrane of sperm, which is composed of phospholipids containing [poly]unsaturated fatty acyl residues that are highly vulnerable to radical damage. This can lead to changes in sperm motility and its ability to fertilize oocytes. Second, an excess of radicals can cause sperm DNA fragmentation [SDF], resulting in impaired genetic contributions from the father to the development of the embryo [4].

Researches indicate that being overweight or obese can change the structure and function of accessory glands. Therefore, evaluating the chemical markers of these glands could be crucial in identifying any changes caused by excess body weight [5].

The main aim of the present study is to evaluate effect of obesity on markers of accessory glands [epididymis, seminal vesicles and prostate] and seminal parameters [volume, concentration, morphology, motility, viability] in infertile men.

PATIENTS AND METHODS

A comparative cross-sectional study has been conducted at the outpatient clinic of Dermatology and Andrology Department, Al-Azhar University Hospital of Damietta from May 2020 to March 2022. The study included 50 male infertile patients [Either primary or secondary infertility] who were divided into 2 groups according to BMI:

Group 1 [control group]: included 25 infertile male patients with BMI [18-25 kg/m^2].

Group 2 [study group]: included 25 infertile male patients with BMI [≥ 25 kg/m^2].

Patients diagnosed with genito-urinary conditions such as infections, prostatitis, hydrocele, pain, torsion, bleeding, inflammation, Azoospermia, post- surgery as varicocelectomy [duration ≤ 6 months] and varicocele were excluded.

Before being included in the study, all participants were required to provide written informed consent, which outlined the importance of the research and the procedures that would be carried out. The study adhered to the Helsinki Standards as updated in 2013, and the entire research design was approved by the Local Ethics Committee, Al-Azhar University Hospitals [IRB00012367 - 21-03-003].

The Body Mass Index [BMI] is calculated by dividing an individual's weight in kilograms by the square of their height in meters [kg/m2]. A BMI value ranging between 18.5 and 24.99 kg/m2 is considered normal. Those with BMI values between 25 and 29.9 kg/m2 are classified as overweight, while those with values greater than 30 kg/m2 are considered obese [6].

Semen analysis

Semen samples were acquired through masturbation into a sterile plastic container following a period of sexual abstinence of at least 2 days but no more than 7 days. The samples were allowed to liquefy at 37 °C and were analyzed within an hour of liquefaction. All samples were assessed based on the WHO 2021 criteria [7]. Standard manual semen analysis was used to obtain the following parameters: ejaculate volume, sperm concentration, motility [percentage of moving sperm], progressive motility [scored on a scale of 1 [poor] to 4 [best]], pH [acidity of the fluid], and sperm morphology [appearance].

Computer assisted semen analysis

Semen analysis was conducted through the use of sophisticated electronic imaging system and an advanced software program to visualize the sperm. The microscope's stage is used to hold the semen specimen, and a high-resolution video camera is attached to the microscope. The video camera captures data that is then input into the computer and analyzed by software.

Semen analysis and sperm motility

During computerized semen analysis, the computer is able to detect and monitor every sperm present within the microscopic field. The path the sperm takes is analyzed over a fraction of a second, allowing for the computation of several different parameters with a high level of precision.

The image depicted below shows individual sperm paths represented by squiggly green lines, while non-moving sperm are marked with red dots.

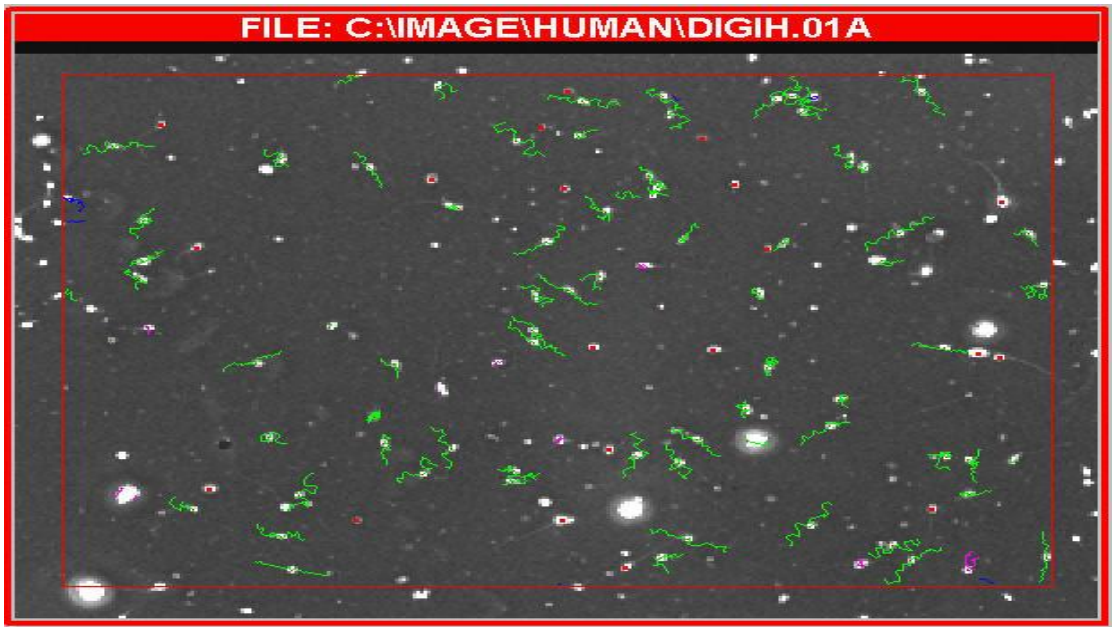

Figure [1]: Semen analysis: Concentration and motility

The calculated parameters include:

- **Overall motility**-Percent of sperm showing any movement.
- **Rapid motility**-Percent of sperm traveling at a speed of 25 um/sec or faster.
- **Progressive motility**-Percent of sperm moving rapidly and in a straight path.
- **Linearity**-Percent of sperm moving in a straight-line path.
- **Mean velocities**-An average speed for all sperm in the field of view.
- **Amplitude of lateral head displacement**-The average distance that the sperm head "wiggles" back and forth while moving.

To determine morphology, Ee have opted to use a computer assisted system [8].

Biochemical analysis: Chemical markers related to epididymis [Neutral alpha-glucosidase: NAG], prostate [citric acid], and seminal vesicles [fructose] functions were evaluated. The concentration of fructose and citric acid in semen were determined using commercially available testing kits from Boehringer Mannheim GmbH [Mannheim, Germany]. The hexokinase method was used to measure the fructose concentration, while the citric acid level was measured using citrate lyase with the formation of NADPH, which was then measured by its light absorbance at 365 nm [9].

Statistical analysis

Using SPSS [statistical package for the social sciences] version 21, data input and statistical analyses were carried out [SPSS Inc., Chicago, IL, USA]. Mean and standard deviation were calculated to express continuously distributed, normally distributed data. The Kolmogorov-Smirnov test has been used to determine the normality of the quantitative data. Continuous normally distributed data will be analyzed using the independent sample t test [student t test]. For continuous multivariate data that were regularly distributed, the analysis of variance [ANOVA] test was utilized. Statistical significance was considered when the probability [P] value was found to be less than or equal to 0.05.

RESULTS

In group 1, the mean age was 30.5 ± 7.1 years while in group 2 the mean age was 32.4 ± 4.6 years, without any statistically significant difference between the two groups. There were 1 case [4%] and 4 cases [16%] with DM in the group 1 and group 2 respectively without statistically significant difference between both groups. In group 1, there were 15 cases [60%] with primary infertility and 10 cases [40%] with secondary infertility while in group 2 there were 14 cases [56%] with primary infertility and 11 cases [44%] with secondary infertility without statistically significant difference between both groups [table 1].

The median volume of semen in group 1 was 3.5 ml [2.3-10.5] while in group 2, the median volume was 2.5 ml [1.3 – 6.5]. The semen volume has been statistically significantly higher in group 1 as compared to group 2. In group 1, median of sperm count was 40 [22.6 - 101.7] while in group 2, the median sperm count was 5.1 [0.1 – 15.8]. The sperm count was statistically significantly higher in group 1 in comparison with group 2. No statistically significant difference has been found in the PH and liquefaction time between group 1 and group 2. Semen colour was grey in 16% and whitish in 84% of the cases in group 1 while was grey in 24% and whitish in 76% of the cases in group 2 with no statistically significant difference between the two groups. There were 20 cases [80%] and 17 cases [68%] with normal semen viscosity in group 1 and group 2 respectively without any statistically significant difference between both groups. Complete liquefaction of semen was detected in 20 cases [80%] and 17 cases [68%] in group 1 and group 2 respectively with no statistically significant difference between the two groups. Abnormal agglutination was detected in 4 cases [16%] and 8 cases [32%] in group 1 and group 2 respectively without any statistically significant difference between both groups. No statistically significant difference was shown in the WBCs count and RBCs count between the cases in the two study groups [Table 2].

The median total motility ratio of sperms in group 1 was 64.9 % [26.7 - 92] while in group 2, the median total motility ratio was 46.7 % [6.7 – 87]. The total motility ratio was statistically significantly higher in the first group compared to the second group. The median progressive motility ratio of sperms in group 1 was 41.1 % [15.6 – 73.9] while in group 2, the median progressive motility ratio was 29.4% [0 – 37.1]. The progressive motility ratio has been statistically significantly higher in group 1 when compared to group 2. Also, no statistically significant difference was indicated in the non-progressive motility, VCL, VSL, VAP, LIN, WOB and LIN between the cases in both of the study groups. The percentage of the median of sperms with normal morphology in group 1 was 13.3% [4.6 - 34] while in group 2, the median percentage of sperms with normal morphology was 9.5% [0 – 23.3]. The percentage of sperms with normal morphology was statistically significantly higher in group 1 in comparison with group 2. The mean ratio of terato-sperms in group 1 was 84.8 ± 8.2% while in group 2, the mean ratio of terato-sperms was 91 ± 7.5%. The percentage of terato-sperms was statistically significantly lower in group 1 as compared to group 2. The median pin head in group 1 was 0.41 [0.1 – 2.6] while in group 2, the median pin

head was 0.13 [0 – 1.1]. The pin head was statistically significantly higher in group 1 as compared to group 2. The mean MAI in group 1 was 1.7 ± 0.2 while in group 2, the mean MAI was 1.8 ± 0.3. The mean MAI was statistically significantly lower in group 1 as compared to group 2. In addition, no statistically significant difference was shown in the percentage of head abnormality, percentage of neck midpiece abnormality, percentage of tail abnormalities, cytoplasmic droplets, teratozoospermic index and sperm deformity index [table 3].

The mean fructose level in group 1 was 197.1 ± 49.7 mg/dl while in group 2, the mean fructose level was 417.7 ± 73.1 mg/dl. The mean fructose level in group 1 was statistically significantly lower when compared to group 2. The median citric acid level in group 1 was 365 mg/dl [256.9 – 523.3] while in group 2, the median level of citric acid was 130.5 mg/dl [50.4 – 222]. The median citric acid level in group 1 was statistically significantly higher when compared to group 2. The median alpha glucosidase level in group 1 was 6.1 mg/dl [4.3 – 18.4] while in group 2, the median level of alpha glucosidase was 3.6 mg/dl [2.9 – 10.2]. The median alpha glucosidase level in group 1 was statistically significantly higher in comparison with group 2 [table 4].

In the cases in group 1, no statistically significant correlation was indicated between fructose level with any of the included variables, while a statistically significant positive correlation was indicated between citric acid level and Alpha glucosidase level while other variables didn't reveal a correlation that is statistically significant. A statistically significant negative correlation was shown between Alpha glucosidase level with pin head while other variables didn't reveal a statistically significant correlation [table 5].

In the cases of group 2, no statistically significant correlation was shown between accessory gland markers with any of the included variables [table 6].

Table [1]: Age, associated chronic diseases and type of infertility in the two study groups

Items		Group 1 [control group] BMI [18-25 kg/m^2] n= 25	Group 2[study group] BMI [≥ 25 kg/m^2] n= 25	Test	P value
Age [Years]		30.5 ± 7.1	32.4 ± 4.6		0.262
Diabetes mellitus [n [%]]		1 [4%]	4 [16%]	2.001	0.157
Hypertension [n [%]]		1 [4%]	1 [4%]	0	1
Type of infertility [n [%]]	**Primary** **Secondary**	15 [60%] 10 [40%]	14 [56%] 11 [44%]	0.082	0.747

Table [2]: Comparison of physical semen characters, WBCs and RBCs count in the two study groups

Items		Group 1 BMI [18-25 kg/m^2] n= 25	Group 2 BMI [≥ 25 kg/m^2] n= 25	Test	P
Volume [ml] [median [range]]		3.5 [2.3 – 10.5]	2.5 [1.3 – 6.5]	z = -4.921	**0.003***
Sperm count [mil/ml] [median [range]]		40 [22.6 - 101.7]	5.1 [0.1 – 15.8]	z = -6.064	**< 0.001***
PH [mean ± SD]		7.8 ± 0.3	7.63 ± 0.3	t = 1.789	0.080
Colour [n [%]]	Grey Whitish	4 [16%] 21 [84%]	6 [24%] 19 [76%]	FET = 1.501	0.280
Viscosity [n [%]]	High Normal	5 [20%] 20 [80%]	8 [32%] 17 [68%]	χ^2 = 0.936	0.333
Liquefaction time [min] [mean ± SD]		30.6 ± 1.3	31.6 ± 2.5	t = -- 1.705	0.098
Liquefaction state	Complete Incomplete	20 [80%] 5 [20%]	17 [68%] 8 [32%]	χ^2 = 0.936	0.333
Agglutination detected [n [%]]		4 [16%]	8 [32%]	FET = 2.348	0.112
WBCs [mil/ml] [median [range]]		0.4 [0.2 – 4.2]	0.4 [0.3 – 6.2]	z = -0.358	0.721
RBCs [mil/ml] [median [range]]		0.1 [0.1 – 1.2]	0.1 [0.1 – 2.1]	z = - 1.295	0.195

Table [3]: Comparison of sperm motility report and sperm morphology report in the two study groups by CASA

Items	Group 1 [Control group] BMI [18-25 kg/m^2] n= 25	Group 2 [Study group] BMI [≥ 25 kg/m^2] n= 25	P value
Total motility ratio [PR+NP] [%]	64.9 [26.7 - 92]	46.7 [6.7 – 87]	**0.018***
Progressive motility [%]	41.1 [15.6 – 73.9]	29.4 [0 – 37.1]	**0.011***
Non-progressive motility	21.4 [10.7 – 36]	17.7 [6.7 – 42.3]	0.156
Immotile sperms [%] [median [range]]	35.1 [8 – 73.3]	53.3 [13.1 – 93.3]	**0.018***
Velocity along the curvilinear [median [range]]	19.8 [8.9 – 37.1]	16.2 [0.6 – 73.1]	0.077
Velocity along the straight-line [median [range]]	15.3 [5.8 – 31.5]	10.9 [0.3 – 33.4]	0.148
Velocity along the average path [median [range]]	17.3 [6.6 – 36.8]	13.1 [0.3 – 37.6]	0.174
linearity of the curvilinear path [mean ± SD]	0.7 ± 0.1	0.7 ± 0.2	0.885
Sperm morphology			
Normal morphology [%] [median [range]]	13.3 [4.6 - 34]	9.5 [0 – 23.3]	**0.012***
Terato-sperms [%] [mean ± SD]	84.8 ± 8.2	91 ± 7.5	**0.007***
Head abnormality [%] [mean ± SD]	81 ± 19.6	94.7 ± 31	0.068
Neck midpiece abnormality [%] [median [range]]	21.1 [10.5 – 51.4]	23.9 [6.9 – 87.1]	0.627
Tail abnormality [%] [median [range]]	20.7 [6.5- 45.6]	29.6 [3.2 – 68.4]	0.065
Cytoplasmic droplets [median [range]]	13.8 [3.3 – 42.3]	14.3 [0 – 48.2]	0.985
Pin head [median [range]]	0.41 [0.1 – 2.6]	0.13 [0 – 1.1]	**0.011***
Multiple Anomalies Index [mean ± SD]	1.7 ± 0.2	1.8 ± 0.3	**0.047***
Teratozoospermic index [mean ± SD]	1.6 ± 0.2	1.6 ± 0.3	0.339
Sperm deformity index [mean ± SD]	1.5 ± 0.3	1.7 ± 0.4	0.058

Table [4]: Comparison of fructose, citric acid and alpha glucosidase level in the two study groups

Items	Group 1 [Control group] BMI [18-25 kg/m^2] n= 25	Group 2 [Study group] BMI [≥ 25 kg/m^2] n= 25	Test	P
Fructose [mg/dl] [mean ± SD]	197.1 ± 49.7	417.7 ± 73.1	t = -12.481	< **0.001***
Citric acid [mg/dl] [median [range]]	365 [256.9 – 523.3]	130.5 [50.4 – 222]	z = -6.064	< **0.001***
Alpha glucosidase [mg/dl] [median [range]]	6.1 [4.3 – 18.4]	3.6 [2.9 – 10.2]	t = -5.272	< **0.001***

t: student t test; z: Mann-Whitney test

Table [5]: Correlation between accessory gland markers with other variables in group 1

Variables	Fructose		Citric acid		Alpha glucosidase	
	r	P	r	P	r	P
Age	-0.009	0.966	0.006	0.976	-0.123	0.558
Semen volume	-0.292	0.157	0.220	0.290	0.109	0.605
sperm count	-0.372	0.067	0.082	0.696	0.156	0.457
PH	0.231	0.267	0.213	0.307	0.203	0.246
liquefaction time	-0.053	0.800	-0.167	0.425	-0.262	0.206
White Blood Cells	0.163	0.435	-0.157	0.452	-0.387	0.056
Red Blood Cells	-0.165	0.430	0.290	0.160	0.188	0.369
Total motility	-0.008	0.972	0.069	0.744	0.387	0.056
Progressive motility	-0.027	0.898	0.093	0.657	**0.469***	**0.018**
Non-progressive motility	-0.152	0.467	-0.113	0.591	-0.029	0.890
Immotile sperms	0.008	0.972	-0.069	0.744	-0.387	0.056
VCL	-0.023	0.913	0.188	0.368	0.341	0.067
VSL	0.029	0.890	0.260	0.209	0.269	0.118
VAP	0.016	0.939	0.237	0.253	0.164	0.219
LIN	-0.061	0.771	0.174	0.405	0.327	0.110
Normal morphology	-0.211	0.312	0.129	0.538	0.135	0.521
Teratosperms	0.211	0.312	-0.129	0.538	-0.135	0.521
pin head	-0.106	0.614	-0.192	0.358	**-0.463***	**0.020**
Multiple Anomalies Index	0.025	0.905	-0.133	0.526	-0.127	0.545
Teratozoospermic index	0.036	0.863	-0.197	0.346	-0.196	0.347
Sperm Deformity Index	-0.059	0.779	-0.261	0.207	-0.287	0.164
Fructose	-	-	-0.071	0.736	0.005	0.982
Citric acid level	-0.071	0.736	-	-	**0.399***	**0.048**
Alpha glucosidase	0.005	0.982	**0.399***	**0.048**		

VCL: Velocity along the curvilinear; VSL: Velocity along the straight-line; VAP: Velocity along the average path; LIN: linearity of the curvilinear path.

Table [6]: Correlation between accessory gland markers with other variables in group 2

Variables	Fructose		Citric acid		Alpha glucosidase	
	r	P	r	P	r	P
Age	0.124	0.553	-0.208	0.318	0.203	0.331
Semen volume	0.210	0.313	-0.196	0.347	0.196	0.349
sperm count	-0.107	0.612	0.034	0.872	-0.348	0.088
PH	-0.095	0.653	0.211	0.312	-0.111	0.599
liquefaction time	0.084	0.689	0.055	0.794	0.237	0.254
White Blood Cells	-0.235	0.258	0.221	0.288	0.205	0.325
Red Blood Cells	0.053	0.803	-0.054	0.796	0.378	0.062
Total motility	-0.100	0.633	0.115	0.585	-0.025	0.904
Progressive motility	-0.084	0.690	0.167	0.426	0.030	0.888
Non-progressive motility	0.089	0.674	0.123	0.559	0.099	0.638
Immotile sperms	0.100	0.633	-0.115	0.585	0.025	0.904
VCL	-0.060	0.776	0.145	0.489	-0.068	0.748
VSL	-0.023	0.913	0.198	0.342	0.013	0.952
VAP	-0.021	0.922	0.183	0.382	0.016	0.940
LIN	0.101	0.630	0.117	0.578	0.205	0.326
Normal morphology	-0.275	0.184	0.152	0.469	-0.203	0.331
Teratosperms	0.294	0.153	-0.163	0.436	0.236	0.255
pin head	0.009	0.966	0.119	0.572	0.060	0.776
Multiple Anomalies Index	0.228	0.233	-0.070	0.741	0.108	0.608
Teratozoospermic index	0.311	0.141	-0.117	0.578	0.191	0.361
Sperm Deformity Index	0.378	0.063	-0.025	0.905	0.103	0.625
Fructose	-	-	-0.051	0.808	0.352	0.084
Citric acid level	-0.051	0.808	-	-	0.144	0.493
Alpha glucosidase	0.352	0.084	0.144	0.493	-	-

VCL: Velocity along the curvilinear; VSL: Velocity along the straight-line; VAP: Velocity along the average path; LIN: linearity of the curvilinear path.

DISCUSSION

Recent researches have confirmed that weight loss in obese men is linked to an improvement in sperm parameters. However, exploring the direct negative influence of BMI increase on the quality of the ejaculate is challenging [10].

In the current study, the semen volume was statistically significantly higher in group 1 when compared to group 2. According to **Kozopas *et al.*** [11], the semen volume in the overweight cases was 3.5 [1.0-9.5] ml that was lower when compared with the normal weight cases, but it didn't achieve a statistically significant value. Also, according to **Lozano-Hernández *et al.*** [5], the semen volume did not show any meaningful statistical difference between infertile cases of normal weight and overweight cases.

According to findings from the Longitudinal Investigation of Fertility and the Environment [LIFE] study, there is a direct relationship between high BMI and greater occurrence of low semen volume, with a statistically significant correlation [P = 0.01] [12]. Although not statistically significant, **Chavarro *et al.*** [13] discovered a trend of reduced semen volume as BMI increased. This is consistent with the findings of a meta-analysis of 31 studies, which also found no significant correlation between BMI and semen volume [14].

The median sperm count in group 1 was 40 [22.6 - 101.7] while in group 2, the median sperm count was 5.1 [0.1 – 15.8]. The sperm count was statistically significantly higher in group 1 when compared to group 2. This is in agreement with **Lozano-Hernández *et al.*** [5] and **Kozopas *et al.*** [11] who indicated that the sperm count was statistically significantly lower in the overweight and obese cases in comparison with the normal weight cases. Moreover, **Maghsoumi-Norouzabad *et al.*** [15] demonstrated that obese infertile men had significantly lower sperm counts [P<0.001] compared to infertile men with normal weight. A larger meta-analysis comprising 21 studies involving over 13,000 men found strong evidence of obesity's significant impact on spermatogenesis. The study documented that obesity was associated with both oligospermia and azoospermia, with odds ratios of oligospermia being 1.11 [1.01-1.21] for overweight participants and 1.28 [1.06-1.55] for obese men. The odds ratio rose to 2.04 [1.59-2.62] for morbidly obese individuals [16].

Researches has demonstrated that obese men are three times more likely to have oligospermia, which is characterized by a sperm count of fewer than 15 million/ml, when compared to healthy men with normal weight [17]. Another study, which examined American couples planning to conceive, discovered that there was a decrease in sperm concentration with increasing waist circumference, as well as a reduction in ejaculate volume with increasing BMI [12].

Two recent meta-analysis studies have examined how BMI is related to semen characteristics, as well as sperm concentration and total sperm count. **MacDonald *et al.*** [14] could not establish any correlation, but the study's analysis was restricted by a small number of studies that were included. **Sermondade *et al.*** [18]'s group involved numerous studies and more than 13,000 males.

Studies examining the correlation between BMI and sperm motility have yielded varied results. In this particular study, the normal weight group had statistically significantly higher percentages of total motility and progressive motility compared to the overweight group. Additionally, the overweight cases had a statistically significantly higher percentage of immotile sperms compared to the normal weight group. These findings were consistent with previous research by **Kozopas *et al.*** [11], which also reported that the normal weight group had statistically significantly higher percentages of total motility and progressive motility compared to the overweight group. The results were also in line with **Maghsoumi-Norouzabad *et al.*** [15], who found that total motility [P<0.001] and progressive sperm [P<0.001] were significantly lower in obese groups when compared to normal weight infertile males.

However, **Lozano-Hernández *et al.*** [5] didn't show a statistically significant difference in the percentage of total sperm motility among normal, pre-obese, obesity grad I and obesity grade II-III infertile men included in their study.

Several studies did not find any correlation between BMI and sperm total motility [19, 20]. **MacDonald *et al.*** [14], in their meta-analysis, were also unable to establish a significant correlation between sperm motility and BMI. In this study, although an inverse relationship between sperm motility and BMI was observed, it did not reach statistical significance [P = 0.343].

In the current study, the ratio of sperms with normal morphology was significantly higher in group 1 when compared to group 2. The percentage of terato-sperms was statistically significantly lower in group 1 when compared to group 2. Also, the pin head was statistically significantly higher in group 1 when compared to group 2. The mean MAI [Multiple Anomalies Index] was statistically significantly lower in group 1 as compared to group 2. In accordance with our results, **Hofny *et al.*** [21] stated a significant positive correlation between BMI and abnormal sperm morphology. This disagreed with **Keszthelyi *et al.*** [22] who didn't report any significant difference in the percent of normal sperm morphology between the cases with average body weight and overweight infertile men included in their study. Within the same line, **Puri *et al.*** [23] showed that the incidence of abnormal sperm morphology was higher in the obese and overweight groups as compared to the normal reference group. However, the difference was statistically insignificant [P > 0.05]. **Alshahrani *et al.*** [24] did not observe a significant relationship between BMI and sperm morphology. Same findings were demonstrated by other studies [13, 14, 25].

In the present study, the mean fructose level in group 1 was statistically significantly lower when compared to group 2. This is in agreement with **Lozano-Hernández *et al.*** [5] who indicated that fructose concentrations were 47.6 ± 41.3 µmol/ejaculate, 51.1 ± 49 µmol/ejaculate, 50.0 ± 39.3 µmol/ejaculate and 55.5 ± 29.2 µmol/ ejaculate in normal, pre-obese, obesity grad I and obesity grade II-III infertile men respectively. Overweight and obese men have higher levels of adiponectin and fructose in their seminal plasma when compared to men with normal weight.

Fructose is a type of carbohydrate that is transported into sperm and serves as a significant energy source. It is currently unknown if the elevated fructose levels in the seminal plasma of obese men can account for changes in sperm mitochondrial function [26].

However, the present findings contradict the results of **Kozopas *et al.*** [11], who observed a 23% reduction in fructose levels [µmol/ejaculate] in the pre-obesity group as compared to the control group [P < 0.05].

The reduction in fructose levels observed in individuals with normal weight can be attributed to several factors. Firstly, an increase in sperm concentration is often accompanied by a decrease in fructose concentration in seminal plasma, owing to the fact that sperm utilize fructose as their primary source of energy. Additionally, it could be caused by increased sperm motility or inflammation of the seminal vesicles. Lower levels of testosterone secretion or anatomical abnormalities may also play a role [27].

Zinc's primary ligand is likely citrate. Citric acid levels are regulated by testosterone and, similar to fructose, can be elevated in individuals with oligozoospermia and azoospermia without a clear clinical explanation [28]. Citrate is a crucial anion that has an affinity for calcium, magnesium, and zinc. A significant proportion of seminal citrate is a strongly charged anion [29].

In the current study, the median citric acid level in group 1 was 365 mg/dl [256.9 – 523.3] while in group 2, the median level of citric acid was 130.5 mg/dl [50.4 – 222]. The median citric acid level in group 1 was statistically significantly higher as compared to group 2. This disagreed with **Lozano-Hernández *et al.*** [5] who showed that the citric acid level was 99.2 ± 79.7 mmol/ejaculate, 105.7 ± 80.8 mmol/ ejaculate and 111.1 ± 85.3 mmol/ejaculate in the normal, pre-obese, obesity grad I infertile men respectively. This also contradicts the results of **Kozopas *et al.*** [11] who showed that the pre obesity group showed an increase in citric acid [µmol/ejaculate] levels by 27% as compared to the controls.

The researchers clarified that the disparities observed were due to the fact that citric acid has antioxidant and anti-inflammatory properties in tissues that have been affected by environmental factors. The increase in citric acid concentration in the pre-obese group samples was linked to low-grade systemic inflammation and oxidative stress [30].

In recent years, an essential marker for epididymis secretion has emerged: α-1,4 neutral alpha glucosidase [NAG], which has two forms, one acidic and prostatic in origin, and the other neutral and epididymal in origin. The neutral isoform is primarily secreted in the body of the epididymis and is involved in the maturation of spermatozoa [31]. While L-carnitine and glycerol-phosphorylcholine have been used as biomarkers for epididymal function in the past, NAG is now considered the most sensitive and specific marker for the epididymis [32].

In this study, the median alpha glucosidase level in group 1 was 6.1 mg/dl [4.3 – 18.4] while in group 2, the median level of alpha glucosidase was 3.6 mg/dl [2.9 – 10.2]. The median alpha glucosidase level in group 1 was statistically significantly higher when compared to group 2. This is in agreement with **Lozano-Hernández *et al.*** [5] who showed that the Neutral alpha glucosidase level was 23.3 ± 13.5 mUI/ejaculate, 21.9 ± 13.5 mUI/ejaculate, 21.4 ± 12.2 mUI/ejaculate and 19.8 ± 14.1 mUI/ejaculate in normal, pre-obese, obesity grad I and obesity grade II-III infertile men respectively. In seminal plasma of overweight and obese men adiponectin, alpha glucosidase levels are lower than in men with normal weight.

Obesity may affect male fertility directly or indirectly through several possible mechanisms, by alterations in hormonal profiles. In human beings, increase in BMI reduces plasma sex hormone-binding globulin [SHBG] that results in lower testosterone and higher oestrogen levels [1, 33, 34]. Furthermore, the condition of obesity itself contributes to elevated oestrogen levels as a result of increased white adipose tissue [35].

Obesity can raise scrotal temperatures by increasing scrotal adiposity, which can harm spermatogenesis and impair semen parameters, such as decreased total sperm count, intensity, and motility, and increased DNA fragmentation index. However, a recent meta-analysis has concluded that there is inadequate evidence to establish a positive relationship between BMI and sperm DNA fragmentation [18, 36].

There is a suggestion that obesity can directly impact spermatogenesis and Sertoli cell function, as evidenced by a more significant decline in inhibin B levels than in FSH levels [37]. Furthermore, it has been proposed that obesity can directly contribute to semen abnormalities by triggering the production of reactive oxygen species [ROS] and inflammatory mediators, which can damage testicular and epididymal tissues [36, 38].

The seminal plasma of obese men was found to have increased levels of inflammatory mediators such as TNF-α and IL-6, as well as decreased levels of vascular endothelial growth factor [VEGF], which could potentially impact semen quality [36].

Conclusion: The findings suggest that obesity gradually and subtly impairs both sperm and prostatic functions, leading to a decline in sperm quality as BMI increases. These results imply that obesity may be a detrimental factor in male infertility. Although traditional sperm parameters may remain largely unchanged, the severity of oxidative stress, hormonal imbalances, and metabolic changes tends to increase as adiposity rises.

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