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The Impact of Body Mass Index on Semen Parameters: A cross sectional study

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Abstract

Introduction: Infertility is an emerging health issue across the world/. Obesity is another growing health concern, which is seen associated with adverse health outcomes. Several people had investigated the effects of obesity on male infertility, with inconclusive findings. Hence the present study aimed to assess the relationship between Body Mass Index (BMI) and the various parameters of semen (volume, sperm count, vitality, motility and morphology).

Methods: This was a cross-sectional study involving 272 men aged 20 – 52 years. The participants were categorized into four BMI groups as underweight, normal weight, overweight, and obese. Semen samples were analyzed. In the correlation study, Spearman's correlation was used. Independent variables were tested on the dependent variables using Analysis of Variance (ANOVA) and Multivariate Analysis of Variance (MANOVA) to find out the effects of BMI on semen parameters while controlling effects of various covariates (age, smoking and alcohol consumption, occupation, ethnicity and education).

Results: Correlation analysis showed no statistically significant correlations between BMI and semen parameters. However, comparing the BMI groups revealed statistically significant differences in semen parameter ($p<0.05$). The normal weight, overweight and obese groups had better semen quality than underweight. Underweight men had sperm count(16±20.78 million/ml), vitality(13.6±7.09%), progressive motility(4.33±4.93%) and morphology(1.33±0.57%). The effect of BMI on semen parameters was further confirmed by MANOVA study with Wilks' Lambda=0.802, F=3.273, $p<0.05$.

Conclusion: Semen quality was adversely affected in underweight groups compared to other groups. Thus emphasizing importance of keeping healthy BMI in order to have a better reproductive health.

Keywords: BMI, semen parameters, underweight.

Introduction

Infertility is one of the major health concern as it affects a significant part of world's population with prevalence rate of life time is around 17.5%.[1] Males are seen sole responsible in 20-30% cases of infertility and 50% of overall cases.[2] Risk factors that predisposes to male infertility include tobacco use, alcohol consumption, obesity, varicocele, orchitis, scrotal trauma, increased caffeine intake etc.[3] Infertility due to male factor is confirmed, when semen analysis report has been abnormal for two consecutive times according to World Health Organization (WHO) recommendation.[4]

Variation in the hypothalamic-pituitary-gonadal axis, alteration of steroid synthesis from testis and metabolic dysfunction are the reported pathology behind the negative impact of BMI on semen parameters, including sperm count, motility, viability and morphology.[5] Body

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mass index (BMI), measured as persons weight in kilograms, divided by square of height in meter squared (kg/m2) is a measure used to assess nutritional status of an individual .[6]

Till today, several researches[2,3] have been conducted on causes and risk factors that causes infertility among the infertile couples but literature on the association between BMI and semen quality is scanty and inconclusive. The objective of this study was to study the impact of BMI on different semen parameters like volume, sperm concentration, vitality, total motility, progressive motility and normal morphology.

Methods

This Cross-Sectional Study, assessed the male partners of couple with infertility who attended at infertility Department of infertility at Paropakar Maternity and Women's Hospital, Thapathali, Kathmandu from 2024/3/1 to 2024/6/1. Taking the ethical consideration from both the Institutional Review Board of National Academy of Medical Sciences and hospital itself, participants were enrolled from infertility Out Patient Department (OPD). The fertility status of the female partner was not taken into account. Those men who fulfilled the inclusion criteria i.e. male partner of sub- fertile couple who failed to conceive after one year of unprotected intercourse were selected and informed about the purpose of the study. Written consent was then obtained and data collection was started. Participants with pre-existing medical conditions which were likely to affect the sperm quality like hypertension, diabetes mellitus, chronic renal disease, liver disease, thyroid disorder, orchiectomy for any reason and testicular cancer, recent history of fever, drugs and chemotherapy, semen bacterial contamination and known case of azoospermia were excluded from the study.

Two hundred seventy-two patients were selected by convenience sampling. The sample size was obtained with the formula:

$$= n = \frac{z^2\,pq}{d^2} = \frac{1.96 \times 1.96 \times 0.23(1-0.23))}{(0.05 \times 0.05)} = 272$$

(z =1.96 taken at 95% of confidence interval), n = required sample size, p =Prevalence (prevalence of abnormal semen analysis), q= 1-p d = 5 % (Maximum tolerable error). Prevalence of abnormal semen analysis: 23.6%[7].

Height (cm) and weight (kg) was measured. Height was measured with stadiometer with the participant's eyes as well as ears in same horizontal line and in bare feet. Body weight was measured using a digital scale of Rossmax company model no. WB101, with participants standing in the center of the scale, with minimal clothing and without any help. Body Mass Index was then calculated. Each participant was asked to provide a semen sample by masturbating into a wide-mouthed plastic container provided by andrology laboratory after sexual abstinence of 2-7 days. Samples were immediately sent to laboratory for analysis. Semen samples examinations was conducted by trained clinical technicians. All the semen samples were allowed liquefy for 30 minutes. Samples were investigated within half an hour of being collected. The evaluation of semen samples was done by practicing WHO laboratory Manual for Examination and Processing of Human Semen.[8] The semen sample were analyzed for semen volume, sperm count, sperm motility, and normal sperm morphology. The Makler chamber was used to access the sperm concentration and motility, by placing 10µL of semen onto a Makler chamber and topping it up with cover glass and viewed at 20x magnification. Progressive and non-progressive motility was added to calculate the total motility. For assessment of sperm morphology semen was spread onto a glass slide and air-dried. The so formed smears were stained and morphology was assessed at magnification of 100× and oil emersion. Reporting was then done according to WHO 2021 guideline.[8]

Data collected were analyzed using SPSS ver. 23. Data were expressed as mean (± SD), median (range), or number (percentage). Type of data distribution was determined using histogram. To identify the relation between BMI and each of the semen parameters Spearman Correlation was used. Linear regression analysis was performed and significance of regression coefficients was checked to understand the impact of BMI on each semen parameter. ANOVA followed post hoc test was used to compare the semen parameters across different BMI groups. The analysis was considered significant when p value <0.05. MANOVA test was used to further confirm the relationships between BMI and semen parameters while controlling for confounding factors such as age, occupation, ethnicity, education, smoking and alcohol intake.

Results

A total of 272 participants investigated for infertility were analyzed in the study. The mean age of the study population was 31.5 ± 5.6 years. Comparing the age of the patients, no significant difference was observed among the BMI groups. The mean BMI was 25.19 ± 3.3 kg/m^2 (median 25; range: 15-36). Forty-seven percent of study population had normal BMI and 1.1%, 44.11% and 7.7% were underweight, overweight and obese respectively (Fig 1). Most of the people were Adhiwasi/Janajati (37.1%), 33.8% study population attended Junior high school and services was their commonest occupation (34.9%). Among the total population 72.4% were non-smoker and non-alcoholic (Table 1).

Of all the patients, 48.16% (n=131) had abnormal semen analysis (Fig 2); and 45.04%, 2.29%, 44.27%, 8.40% of normal weight, underweight, over weight and obese people had abnormal semen report (Fig 3). Asthenozospermia was the most common semen abnormality detected i.e. 25.74%(Fig 2). All three underweight patient had abnormal semen report.

Table 1: Characteristics of study population (N=272)

Variables		Mean± Standard deviation or N(%)
Age(Year)		31.52 ± 5.6
BMI(kg/m2)		25.19 ± 3.3
Ethnicity	Brahmin/Chhetri	90 (32.7%)
	Terai/Madesh	35 (12.9%)
	Dalit	36 (13.2%)
	Adiwasi/Janajati	101 (37.1%)
	Others	10 (4%)
Education	Illeterate	4 (1.5%)
	Elementary School	54 (19.9%)
	Junior High School	92 (33.8%)
	Senior High School	49 (18%)
	College	73 (26.8%)
Occupation	Farmer	18 (6.6%)
	Business	72 (26.5%)
	Services	95 (34.9%)
	Labor /Daily Wedges	76 (27.9%)
	None	5 (1.8%)
	Others	6 (2.2%)
Smoker		75 (27.6%)
Alcohol intake		75 (27.6%)

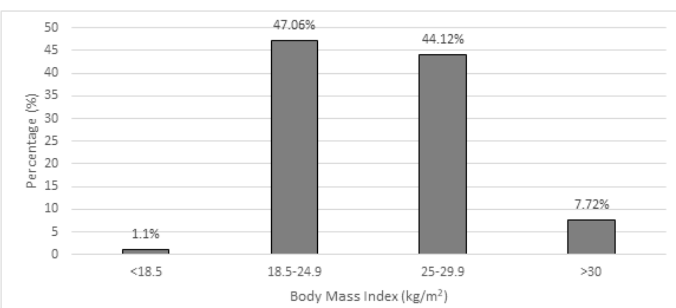

Fig 1: Distribution of Population on BMI

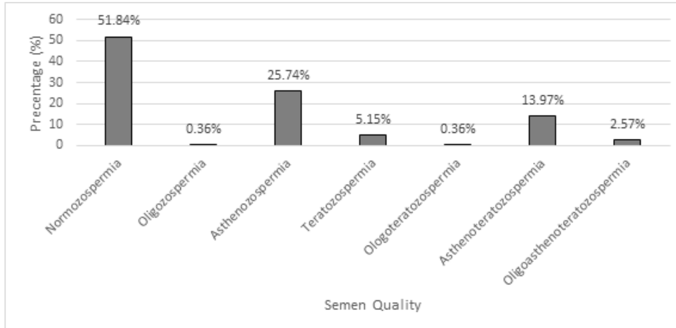

Fig 2: The distribution of population according to sperm quality

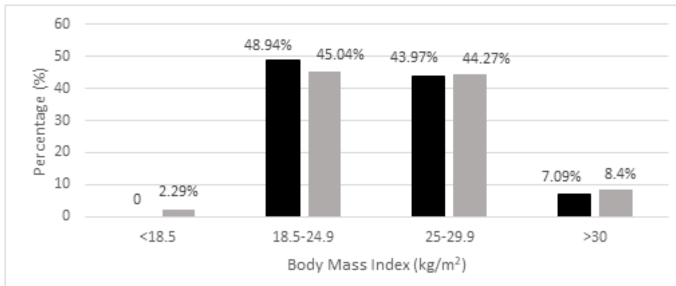

Fig 3: The distribution of patients with semen quality per BMI group

Table 2: Correlation between BMI and different semen parameters

Semen PARAMETERS	BMI	
	R	P value
Volume	-0.02	0.974
Count	0.63	0.302
Vitality	0.35	0.569
Motility	0.22	0.720
Progressive Motility	0.78	0.197
Normal Form	0.11	0.854

There was no statistically significant correlation between BMI and Semen Volume, count, vitality, motility progressive motility and morphology at the 0.05 level (Table 2).

Table 3: Distribution and association of age, semen parameters across BMI groups:

Variables	Patient group by BMI					
	Mean±SD	Under Weight	Normal Weight	Over Weight	Obese	p-value
Age(Year)	31.52 ± 5.6	28.67±7.5	30.78±5.32	32.21±4.62	32.48±4.62	0.143
BMI (kg/m2)	25.19 ± 3.3	16.77±1.45	22.51±1.53	27.10±1.49	31.77±1.83	<0.001
Sperm volume (ml)	4.02 ± 2.52	4.66±4.04	3.97±2.39	3.85±2.45	5.14±3.30	0.180
Sperm concentration (million/ml)	80.4 ± 39.45	16±20.78*	78.25±38.98	85.43±39.31	74.14±36.85	0.012#
Sperm vitality(%)	57.04±17.57	13.6±7.09*	57.67±17.13	57.38±16.42	57.38±20.17	<0.001#
Sperm motility progressive (%)	33.15 ± 16.29	4.33±4.93*	32.75±16.15	33.59±15.08	38.10±20.31	0.009#
Sperm morphology (%)	5.02 ± 1.8	1.33±0.57*	5.02±1.84	5.17±1.84	4.43±2.09	0.002#

= p<0.05, significant difference across the group by ANOVA test

* = p<0.05, for specific BMI group determined by post hoc test (Tukey's HSD)

From the results of the ANOVA test the findings revealed that the total ejaculatory volume was not significantly different between the body mass index groups, on the other hand significant differences were observed in the sperm concentration, live sperm, total motility and progressive sperm motility and the sperm morphology. When we run post hoc test, it was seen that people belonging to the group having BMI less than 18. 5 the sperm quality especially for the total sperm concentration, vitality, motility, progressive motility, and morphology is significantly compared to the other categories presented in Table 2. However, very small sample sizes in the <18.5 BMI group (N=3) could affect the conclusions drawn from this study. If those three samples were excluded from the study, there was no significant differences seen across the BMI groups (p>0.05).

Table 4: Association of semen parameters with other confounders

Confounder	VOLUME (F, p-value)	COUNT (F, p-value)	VITALITY (F, p-value)	MOTILITY (F, p-value)	PERMOT (F, p-value)	MORPHOLOGY (F, p-value)
AGE	0.035, 0.852	0.005, 0.941	11.767. 0.001*	12.713, 0.000*	8.895, 0.003*	0.998, 0.319
BMI	2.452, 0.064	4.446, 0.005*	7.764, <0.001*	7.194, <0.001*	5.330, 0.001*	5.314, 0.001*
ETHNICITY	0.635, 0.426	0.246, 0.621	0.122, 0.727	0.126, 0.723	0.119, 0.731	1.255, 0.264
EDUCATION	0.996, 0.319	0.008, 0.927	8.205, 0.005*	7.543, 0.006*	15.513, 0.000*	1.507, 0.221
OCCUPATION	5.781, 0.017*	3.518, 0.062	0.033, 0.856	0.260, 0.611	0.648, 0.422	0.545, 0.461
SMOKING	5.149, 0.024*	3.415, 0.066	4.034, 0.046*	3.051, 0.082	3.952, 0.048*	0.749, 0.387
ALCOHOLIC	0.258, 0.612	0.650, 0.421	1.270, 0.261	0.890, 0.346	1.138, 0.287	0.456, 0.500

* p<0.05 significant variance using MANOVA test; F= F-statistic

Table 4 showed that the effect of BMI on semen parameters still persisted even after controlling for potential confounders, underscoring its impact in male reproductive function. Age, Smoking, education, occupation was identified as significant confounders affecting multiple semen parameters. Smoking was associated with reduced semen volume, vitality and progressive motility, while education affected vitality and motility. Occupation showed impacts on semen volume.

Discussions

This study showed the significant impact of Body Mass Index (BMI) on various semen parameters, including sperm count, vitality, progressive motility, and morphology even after controlling significant confounding variables like age, smoking and education. However, BMI had no effect on semen volume. Several studies have assessed the impact of BMI on semen parameters however with mixed results. Overweight or obese men have been demonstrated to be affected in matters concerning their semen volumes,[5,9,10] sperm concentrations,[9,11–14] total sperm numbers,[5,9,11,12] sperm motility,[11,12,15] and sperm morphology[11,16.] On the other hand, other studies have not observed an influence of BMI on the semen characteristics between men with normal and high BMI categorized as overweight or obese.[10,17]

Few studies have examined the association between underweight and semen quality. In our study underweight individuals had poorer semen quality i.e. lower sperm count

(16±20.78 million/ml), vitality (13.6±7.09%), progressive motility (4.33±4.93%), and morphology (1.33±0.57%) compared to those with normal weight, overweight, and obese BMI categories. Similar to our study result, most of the studies showed underweight was significantly associated with a reduction in sperm concentration, total sperm number[13,18] and total motile sperm count.[5] Similarly, in a meta-analysis by Sermondade et al. underweight was associated with an increased but non-significant risk of abnormal sperm count.[19]

Some meta-analysis available also show variable results. Two studies concluded that high BMI was associated with decreased sperm quality such as sperm count, concentration, and semen volume rather than sperm motility (overall or progressive).[19,20] However, meta-analysis by MacDonald et al. showed there was no strong evidence for a relationship between BMI and sperm concentration or total sperm count.[21]

Many studies have shown correlation between BMI and semen parameters. Our results conflicted with those published by Kozopas et al., Belloc et al., Håkonsen et. al. and Chih-Wei Tsao et al. where BMI had significant negatively correlation (p=<0.05) with concentration, total number of spermatozoa in the ejaculate, normal morphology, total motility and progressive motility.[11,12,22,23] In a study by Alshahrani et al., BMI also had a negative relationship with semen volume and sperm concentration, motility and morphology but, this relationship reached a significant level only with sperm concentration (P = 0.035).[24] Similar to our study, in a study by Ma et al. and Eisenberg et al. semen volume, sperm concentration, total sperm count, progressive motility, and total progressive motile sperm count and morphology were noted to have no significant correlations with BMI.[5,9]

To further correlate relation of BMI on semen parameters Håkonsen et al. in their pilot cohort study included 43 men with BMI > 33 kg/m2, who participated in a 14-week weight loss program. He concluded that weight loss was associated with an increase in total sperm count and semen volume among men.[22]

The strengths of this study lies on its comprehensive method of analyzing the impact of BMI on semen parameters by using both ANOVA and MANOVA. Study includes a diverse sample population from various ethnic backgrounds, education levels, and occupations thus ensuring that the findings could be applied to a broad group of population. Dividing the population into different BMI categories pointed out on exact BMI categories which was affected. Considering confounding variables like smoking, alcohol intake, age, and education in the analysis, the study has provided a clear and more accurate picture of the relationship. To minimize the laboratory bias, all the samples were analyzed at the same laboratory. Limitations of this study include its cross-sectional design, which prevents causal inference, biases due to self-reported data on confounding factors. Additionally, the single center- based study with relatively small sample size variations across BMI categories may have influenced statistical power and generalizability. Future studies could benefit from larger and more diverse cohorts to validate these findings and explore additional factors influencing male fertility.

Conclusion

This study emphasized the significant impact of BMI and certain confounders (age, smoking, occupation) on semen parameters, particularly the adverse effects of being underweight on sperm quality. However small sample sizes in both the underweight and obese groups have contributed to the lack of significant statistical power to detect significant association. Thus maintaining a healthy BMI is essential for optimal semen quality and overall reproductive health. Further research is needed with larger sample size to explore the relations between BMI, other lifestyle factors, and male fertility.

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