

Does the male BMI affect sperm parameters? A systematic review

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Abstract

Objective: The effect of obesity on male reproductive health has recently gained considerable attention, particularly the effect on sperm parameters. However, studies show a controversial relationship between male obesity and their sperm parameters. This study aimed to systematically review the published literature on the relationship between men's BMI and their sperm parameters.

Method: A comprehensive systematic search of PubMed and SCOPUS databases was conducted to identify relevant research published in the English language from January 2010 to April 2023. Ten studies were determined according to the PRISMA statement for the systematic review, including 19,008 male participants. The first two authors conducted the search strategy independently, and the identified papers were critically appraised before the analysis. Data on sperm parameters such as semen volume, sperm concentration, count, motility, and morphology were systematically extracted into predesigned data extraction sheets. Statistical software SPSS version 25.0 was used for data analysis.

Results: Among the ten studies included in this analysis, four studies with 2391 participants found no statistically significant association between men's BMI and their sperm parameters. In contrast, the remaining six studies involving 16,702 participants showed a statistically significant negative correlation between BMI and sperm concentration, count, and motility ($p < 0.001$, $p = 0.05$, $p < 0.001$, respectively). Nevertheless, the analysis revealed no statistically significant correlation between body mass index and sperm volume ($p = 0.46$) or sperm morphology ($p = 0.14$).

Conclusion: The study results show that BMI significantly affects sperm concentration, count, and motility. However, BMI did not show a significant effect on sperm volume and sperm morphology.

Keywords: BMI, obesity, sperm parameters, systematic review

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Introduction

Infertility is a serious health issue affecting many married couples in our society. The World Health Organization (WHO) defined infertility as a disease of the male or female reproductive system determined by the failure to achieve a pregnancy after 12 months or more of regular unprotected sexual intercourse (1). WHO estimates that 8–12% of couples experience infertility and that 30% of the causes of infertility are related to male factors. Increased body weight is one of many factors that are known to be connected to both female and male fertility (2).

Obesity is a severe health problem that is prevalent all over the world. Four hundred million adults (over the age of 18) are considered obese (BMI > 30 kg/m²), and approximately 1.6 billion are classified as overweight (BMI 25 - 30 kg/m²) (3). Obesity is a serious health risk factor associated with high morbidity and mortality, primarily due to its association with cardiovascular diseases and diabetes (4). There are several methods for measuring obesity. The most widely used indicator for obesity is body mass index (BMI), calculated by dividing a person's weight in kilograms by the square of their height in meters and the waist-to-height ratio calculated by dividing waist circumference by height.

Being overweight or obese is expected to be associated with changes to the male reproductive hormone profile (5). It is already accepted that a high BMI is associated with alterations in the levels of testosterone and estrogens (6). It has also been proposed that if

a relationship between BMI and semen parameters exists, the mechanism for this is likely to involve some alteration of the male reproductive hormone profile, which might also be related to BMI (7). The study done by Sermondade et al., in 2013 showed overweight and obesity were associated with increased prevalence of reduction in sperm motility and oligozoospermia (8). Further, Dan Guo et al., in 2019 have found that there was a relationship between high BMI and semen quality, which suggesting high BMI may be a harmful factor of male infertility (4). On the contrary, a study conducted in 2009 with 6793 males reported that they have failed to find evidence of an association between BMI and sperm parameters (7) and a study done by Relwani et al., in 2011 showed there is no significant association between male BMI and sperm concentration, motility, or morphology (9). Hence, the association between body mass index and sperm parameters remains controversial.

The aim of this study was to conduct a comprehensive systematic evaluation of existing literature about the association between the BMI of men and their sperm parameters.

Materials and Methods

A systematic review of published literature was conducted to study the impact of the BMI of males on their sperm parameters. The protocol of this systematic review was based on the PRISMA protocol. Relevant studies published in the English language from January 2010 to April 2023 were identified

from PubMed and SCOPUS databases using keywords and parentheses as specified below.

Search strategy

The databases that would be searched were identified by authors considering having large databases and widely recognized in the academic and research communities, ensuring the quality and reliability of the sources. Most of the published literatures were covered by these two databases. A list of keywords and phrases related to the research question, encompassing various synonyms and related terms, was developed. Search strings were developed by combining keywords and phrases using Boolean operators (AND, OR) and parentheses to establish the logical structure of the search. After repeated attempts, a good search strategy was developed. Preliminary searches were performed to test the search strategy. The following is used as a search strategy,

(“Anthropometric measurements” or “Body measurements”) and (“BMI” or “Body Mass Index” or “overweight” or “obese” or “weight” or “height”) and (“sperm” or “semen” or “spermatozoa” or “semen parameters” or “seminal parameters” or “sperm quality” or “sperm quantity” or “sperm count” or “sperm motility” or “sperm morphology” or “sperm volume” or “sperm concentration”) and (“seminal fluid analysis” or “semen analysis” or SFA”).

Inclusion and exclusion criteria

The literature on the studies with infertility problems in the female reproductive system and studies with female anthropometric

measurements were excluded as they are outside the scope of this review. Studies on BMI with serum reproductive hormones are also excluded because it is another broad field of study, and it can be a hindrance to this study as well. Further, non-human studies, non-related studies, and full-text non-available studies were excluded.

Types of studies included the studies on BMI with semen volume, BMI with sperm concentration, BMI with sperm count, BMI with sperm motility, and BMI with sperm morphology.

Literature screening

Following the literature retrieval process, two authors independently screened the articles' titles, abstracts, and full texts based on the predetermined inclusion and exclusion criteria. Initially, duplicate articles were removed, followed by titles and abstracts screening. The remaining text was thoroughly examined after excluding articles with unrelated content to verify their inclusion status. Finally, ten studies were included in the analysis.

Quality assessment

The quality assessment of the selected studies was done individually by the first two authors for the ten selected studies. A 5-point scale was used to score each study. The number of study participants, study design and methodology, well-defined exclusion and inclusion criteria, data collection and measurement methods, and achieved objectives were considered here. Two authors compared the scores for each study and if controversial opinions arose, the assistance of a third author was obtained.

Studies that scored $0 - <2$ were regarded as low quality, studies that scored $2 - \leq 3$ were regarded as moderate quality, and studies that scored $>3 - \leq 5$ were regarded as high quality. Only high-quality and moderate-quality studies were considered for further analysis. Among the selected ten studies, three were moderate quality studies and rest of the studies were high quality studies.

Data extraction

Subsequently, data extraction was performed on the included studies using a data extraction form containing study characteristics and outcome data, study information data such as author, publication year, country, study design, participants number and relevant study findings and conclusions (Table 1).

Statistical analysis

Statistical software SPSS version 25.0 was used for data analysis. Analyses were performed using the following BMI categories: 18.5 – 24.9 (normal weight), 25.0 – 29.9 (overweight), and >30 (obese) kg/m². Participants with a BMI between 18.5 and 24.9 kg/m² were considered as the reference group. BMI, sperm parameters and population size (case/control) used as variables in SPSS. Confidence intervals were set at 95%; $p < 0.05$ was considered statistically significant.

Results

The present systematic review included ten articles that met the eligibility criteria. Selected ten were composed of 08 cross-sectional, 01 observational, and 01 cohort studies. The study sample sizes ranged from 80 to 10 665 individuals. From the total of 363 articles (276 articles from PubMed and 87 articles from SCOPUS databases), 245 articles were excluded in the first step. Duplications and articles irrelevant to the primary research question were omitted in the initial screening. Another 71 articles were excluded after carefully examining the titles and abstracts. There were four review articles, two non-human studies, 42 female studies, and 23 studies in which BMI was not measured or had an association with BMI not analyzed. After the full-text article assessment, ten studies were included in the analysis. The literature screening process and the results are shown in Figure 1.

Association between BMI and semen volume

Out of the selected ten studies, 08 studies have evaluated the association between the BMI of males and their semen volume, including 1272 participants in the obese group and 10,305 participants in the control group. Of the above 08 studies, only 03 have shown a significant negative correlation between BMI and semen volume. The results of the analysis showed that BMI was not associated with reduced semen volume (obese versus non-obese controls: $p = 0.46$).

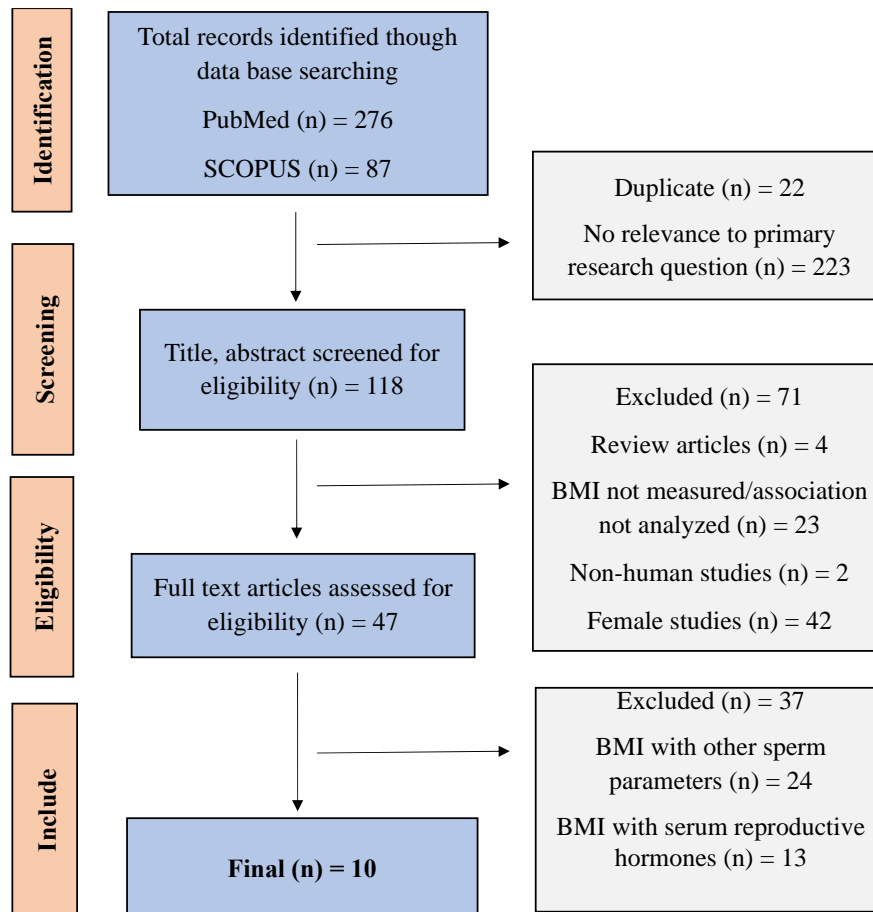


Figure 1: PRISMA statement flow diagram for the systematic review of BMI and semen parameters.

Association between BMI and sperm concentration

Out of the selected ten studies, 09 studies have considered the association between the BMI of males and their sperm concentration, including 1295 participants in the obese group and 10,630 participants in the control group. Out of the above 09 studies, 05 studies have shown a negative correlation between BMI and sperm concentration. The results of the analysis showed that BMI was significantly associated with reduced sperm concentration (obese versus non-obese controls: $p < 0.001$).

Association between BMI and sperm count

Out of the selected ten studies, 07 studies have considered the association between the BMI of males and their sperm count, including 966 participants in the obese group and 9641 participants in the control group. Of the above 07 studies, 04 studies showed a negative correlation between BMI and sperm count. The results of the analysis showed that BMI was associated with reduced sperm count (obese versus non-obese controls: $p = 0.05$).

Table 1: Characteristics and outcomes of the selected studies

Selected Study	Sample size, Abstinence, BMI distribution	Study design, Study variables	Outcomes	Authors conclusions
Al' MD et al., 2015, Sri Lanka (16)	80 3 days 18 – 24.9, 25 – 29.9, ≥ 30	Cross-sectional BMI with semen volume and sperm count.	There is no true significant relationship between semen volume (p = 0.36) and sperm count (p = 0.43) with male BMI.	BMI does not affect sperm parameters
J. Ma et al., 2019, China (10)	3966 2-7 days <18.5, 18.5 – 24.9, 25 – 29.9, ≥ 30	Observational BMI with sperm concentration, sperm count, total motile sperm count, and semen volume.	An increase in obesity was significantly associated with a reduction in sperm count (p = 0.007), sperm concentration (p = 0.042), semen volume (p = 0.010) and total sperm motility (p = 0.036).	BMI affects semen volume, sperm concentration, sperm count, and sperm motility.
Christofolini J, 2014, Brazil (17)	118 NM < 25, 25 – 29.9 ≥ 30	Cross-sectional BMI with semen volume, sperm concentration, Sperm motility and sperm morphology.	Increased BMI shows some reduction in semen volume (p = 0.462). But it was significantly low.	BMI does not affect sperm parameters
Kozopas NM, 2020, Ukraine (11)	152 2-7 days 18.5 – 24.9, 25 – 29.9, ≥ 30	Cross-sectional BMI with semen volume, sperm concentration, sperm count, morphology, and total motile sperm count.	The obese group revealed significantly lower sperm count (p = 0.009), sperm concentration (p = 0.036), total motility (p = 0.006) and normal morphology (p = 0.000).	BMI only affects sperm concentration. Sperm count, motility, and morphology.
Hammiche F et al., 2012, Netherland (12)	450 3-5 days < 25, 25 – 29.9 ≥ 30	Cross-sectional BMI with semen volume, sperm concentration, and total motile sperm count	Obesity is negatively associated with ejaculatory volume (p = 0.02), sperm concentration (p = 0.006), and total motile sperm count (p = 0.007).	BMI affects semen volume, sperm concentration, and sperm motility.
Sekhvat L, 2016, Iran (13)	852 2 days < 18.5, 18.5 – 24.9, 25 – 29.9 ≥ 30	Cross-sectional BMI with total sperm count, sperm concentration, sperm motility, and morphology.	Total sperm count (p = 0.00), sperm motility (p = 0.00), and sperm concentration (p = 0.01) were significantly high in obese men.	BMI affects sperm concentration, motility, and sperm count.
Dubeux VT, 2016, Brazil (14)	158 3-5 days 18.5 – 29.9 25 – 29.9 ≥ 30	Cross-sectional BMI with sperm count, sperm concentration, sperm motility, and morphology.	No significant correlation between sperm count, concentration, motility, or morphology with obesity (p = 0.945) (P = 0.807) (p = 0.764) (p = 0.947).	BMI does not affect sperm parameters

Shayeb AG, 2011 UK (18)	2035 4-6 days < 18.5, 18.5 – 24.9, 25 – 29.9 ≥ 30	Cross-sectional BMI with semen volume, sperm concentration, sperm motility, and morphology	Obese men are likely to have lower semen volume (p = 0.14) and fewer morphology normal sperms (p = 0.40) compared to those men with normal BMI, but it was significantly low.	BMI does not affect sperm parameters
Belloc s, 2014 France (19)	10,665 2-7 days < 18.5, 18.5 – 24.9, 25 – 29.9 ≥ 30	Cross sectional BMI with semen volume, sperm concentration, sperm count, sperm motility, and morphology	Obesity is negatively associated with semen volume (p = 0.01), sperm concentration (p = 0.01), count (p = 0.01), and motility (p = 0.05).	BMI affects semen volume, sperm concentration, count, and motility.
Wen-Hao, 2015 China (15)	617 2-9 days 18.5 - < 25, 25 - < 30, ≥ 30	Cross-sectional BMI with semen volume, sperm concentration, sperm count, sperm motility, and morphology	Obesity was significantly associated with sperm motility (p < 0.05).	BMI affects sperm motility

NM – not mentioned, BMI – body mass index.

Association between BMI and sperm motility

Out of the selected ten studies, 09 studies have evaluated the association between the BMI of males and their sperm motility, including 1326 participants in the obese group and 10,924 participants in the control group. Of the above 09 studies, 05 studies showed a negative correlation between BMI and sperm motility. The results of the analysis showed that BMI was significantly associated with sperm motility (obese versus non-obese controls: p < 0.001).

Association between BMI and sperm morphology

Out of the selected ten studies, 06 studies have

considered the association between the BMI of males and their sperm morphology, including 1185 participants in the obese group and 7694 participants in the control group. Only one study has shown that there was a significant negative correlation between BMI and sperm morphology (p = 0.000). The rest of the studies concluded no significant association between BMI and sperm morphology, including the two most significant studies investigating BMI and semen parameters. The results of the analysis showed that BMI was not associated with sperm morphology (obese versus non-obese controls: p = 0.14).

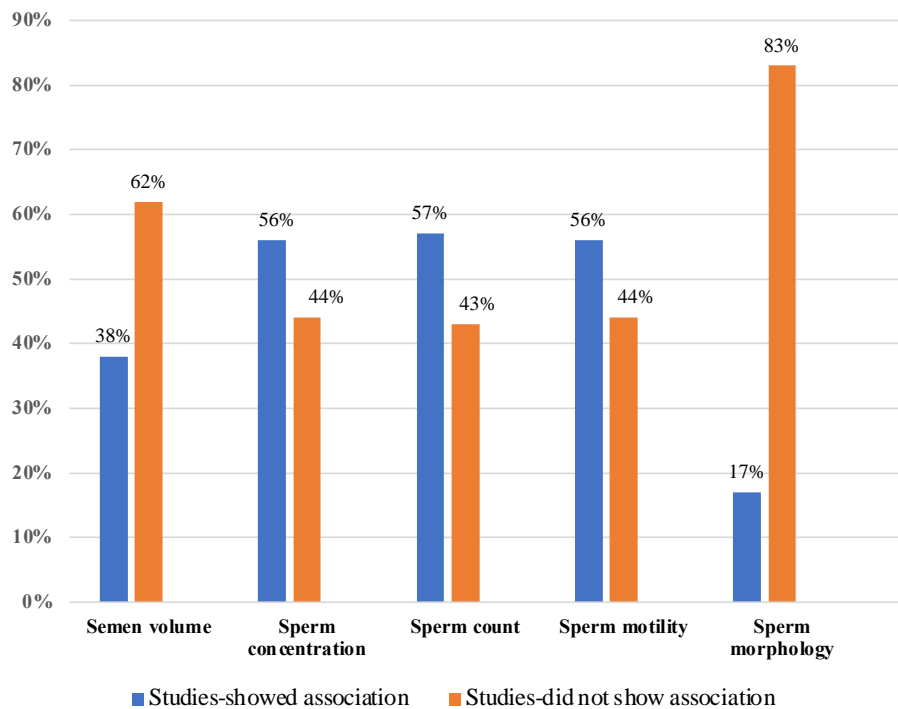


Figure 2: Percentage of studies showing the association between BMI and seminal parameters.

Discussion

This systematic review yielded total of ten studies, with a sample size of 19,008 men. The study comprised eight cross-sectional studies, one observational study, and one cohort study. Out of the selected ten studies, four studies failed to show any statistically significant association between BMI and sperm parameters (14,16,17,18). On the other hand, the remaining six studies have shown significant association between BMI and sperm parameters (10,11,12,13,15,19).

Firstly, regarding semen volume, only 38% of the studies demonstrated a negative correlation between BMI and semen volume. The analysis found no significant association between BMI and reduced semen volume ($p = 0.46$). This suggests a lack of consistent evidence

supporting a direct impact of BMI on semen volume.

However, when considering sperm concentration, most studies (56%) did illustrate a negative correlation between BMI and sperm parameters. The analysis revealed a significant association, showcasing that higher BMI is linked to reduced sperm concentration ($p < 0.001$). These findings align with established knowledge suggesting hormonal disruptions and altered testicular function in individuals with higher BMI, which can reduce sperm concentration (7). Several reports have found that male weight gain has been linked to hormonal abnormalities that impact sex hormone-binding globulin and lower testosterone levels. Since free testosterone and follicular stimulating hormone bear a direct

impact on spermatogenesis, and obesity has an impact on both hormones, it is plausible that sperm concentration may be altered in this patient category (7,15).

Regarding sperm count, seven studies were considered, involving 966 participants in the obese group and 9641 participants in the control group. Among these studies, 57% demonstrated a negative correlation between BMI and sperm count. The analysis from these studies collectively indicated an association between BMI and reduced sperm count, with a reported p-value of 0.05 when comparing obese versus non-obese controls.

The relationship between BMI and sperm motility exhibited similar trends. About 56% of the studies showed a negative correlation, and the analysis confirmed a significant association between BMI and sperm motility ($p < 0.001$). This observation highlights the possible influence of BMI on sperm motility, possibly leading to implications for fertility. The underlying mechanisms linking high BMI to impaired seminal parameters may involve oxidative stress, and inflammation. Oxidative stress associated with obesity may lead to sperm DNA damage and reduced sperm motility (11,14).

Interestingly, sperm morphology demonstrated diverse results. Only 17% of the studies depicted a significant negative correlation between BMI and sperm morphology, while the majority concluded that there was no significant association. This study also did not find a significant relationship between BMI and sperm morphology

($p=0.14$). This suggests that while BMI might not strongly influence sperm morphology.

The study by Belloc in 2014 is possibly the most critical study investigating BMI and semen parameters (19). It has the largest sample size ($n=10,665$) and the broadest study population. Men were recruited from a fertility clinic rather than from a general population setting, and the sample included a substantial amount of overweight and obese men as well as a wide age range. The main limitation of this study was that weight and height were self-reported. The findings of Belloc's study exhibit a degree of resemblance to the outcomes of the present study, indicating a correlation between elevated BMI and reduced semen volume, sperm concentration, and motility. Based on the present study's findings, no statistically significant association exists between BMI and semen volume. Nevertheless, both studies have demonstrated a substantial correlation between BMI, sperm concentration and sperm motility.

Although most of the studies were considered about overweight and obesity, only a few studies have examined the association between underweight and semen quality because underweight subjects generally account for only a small proportion of study populations. Wang B in 2020, found that underweight (defined as $BMI < 18.5 \text{ kg/m}^2$) subjects had a reduction in sperm concentration ($p=0.63$), total sperm count ($p=0.24$), and total motile sperm count ($p=0.51$) but it was not significant (5).

Statistically, these findings illustrate a nuanced view in which BMI exhibits varying degrees of

association with different sperm parameters. While a significant relationship exists between BMI and reduced sperm concentration, count, and motility, the effect on sperm volume and morphology is less. Limitations within these studies, such as diverse participant demographics, methodologies, and potential confounding factors, could contribute to the divergent findings. Additionally, while statistical significance is observed in some associations, the clinical significance regarding fertility outcomes warrants further investigation.

Conclusion

According to the findings of this systematic literature review, BMI has a significant impact on sperm concentration, sperm count, and sperm motility. However, there is no strong evidence for a relationship between BMI and semen volume or sperm morphology based on the studies in this systematic review. Although several studies did report significant relationships between BMI and semen volume as well as sperm morphology, the overall body of research does not support such conclusions. At the very least, if such a relationship does exist, it is not significant enough to be detected by this review.

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