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Male and Female BMI are Not Associated with Copulatory Ejaculate Quality in Committed Couples

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Abstract

In many species, male body mass is negatively associated with ejaculate quality, suggesting that obesity is associated with lower fertility. Large female size (including weight) is a proxy for reproductive quality, and higher-quality ejaculates are allocated strategically to larger females during copulation, which appears inconsistent with the link between obesity and fertility. In the current study, we investigated the impact of human male and female body mass index (BMI) on copulatory ejaculate quality. We calculated the BMI for each individual within 34 heterosexual committed couples (total sample $n = 68$; for couples, $n = 34$; participant ages ranging 18-32 years) and compared the copulatory ejaculate parameter values (averaged from three ejaculates) across three categories (normal, overweight, obese) of male BMI and female partner BMI (BMI categories). Ejaculate quality was not associated with the BMI of male or female partners. The implications of this null finding are discussed, as are the limitations of the current research and directions for future research.

Keywords: copulatory ejaculate quality; committed couples; female BMI; male BMI; prudent sperm allocation

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Ejaculate quality is influenced by features of both male and female morphology across many species (Parker & Pizzari, 2010). Some research suggests that traits indicative of male genetic quality (e.g., immune function, symmetry, size) are associated with ejaculate quality (Parker & Pizzari, 2010; Sheldon, 1994). Additionally, research has identified environmental variables related to differential investment in ejaculate quality at the individual level, including the fecundity of female partners (Kelly & Jennions, 2011). In other words, males may produce a higher-quality ejaculate when copulating with a more fecund female partner. The traits of interest in the current study are ejaculate quality and male and female size, each of which is reviewed in the following sections before we introduce the current research.

Male size and ejaculate quality

Across several insect and mammal species, male size is positively associated with larger testes and a higher rate of sperm transfer during copulation (Parker & Pizzari, 2010; Pochron & Wright, 2002). However, once males reach obesity (i.e. an accumulation of total body fat beyond 10-33% depending on species, often referring to a body mass index [BMI] of 30 or greater in humans; Kuczmarski, 2007), this relationship reverses, and ejaculate quality (a measure of the ability of an ejaculate to accomplish fertilization which includes assessments of quantity and quality of sperm; Darbre, 2015) decreases. Ejaculate parameters that decrease with obesity include sperm motility (which refers to the ability of sperm to swim in a straightforward manner that enable them to reach the egg), sperm concentration (the concentration of sperm within an ejaculate sample in millions per milliliter), and sperm morphology (the percentage of sperm shaped normally and without deformities in head or tail; World Health Organization [WHO], 2022). For example, in an experiment on Wistar rats (*Rattus norvegicus*), males were divided

such that one group received a palm-oil-heavy diet to induce obesity (verified by body weight and total cholesterol concentration) and a control group received a standard diet (balanced in terms of fat, carbohydrates, and protein) for 16 weeks. After the experimental period, obese rats (compared to control-group rats) showed reduced sperm motility, viability (i.e., the proportion of viable sperm compared to non-viable sperm in an ejaculate sample), and normal morphology (Defo et al., 2017). In an experimental study simulating a modern Western diet (i.e. high in fat, fructose, and cholesterol) across a period of 15 months to induce obesity, cynomolgus monkeys (*Macaca fascicularis*), compared to control monkeys, displayed abnormally high testicular expression of genes related to infertility and inflammatory processes associated with chronic inflammation of the testes, along with decreased testosterone, which exacerbated these effects (Zhang et al., 2023).

In humans, obesity is a concern in the United States and other industrialized countries (WHO, 2022). It is associated with metabolic disorders and syndromes, along with a sequela of deleterious effects on many organs, including the endocrine and reproductive systems of both sexes (Katsuri et al., 2008). Obese men are more likely to develop abnormal hormonal profiles compared with non-obese men, most notably for testosterone. Testosterone, the primary male sex hormone, regulates numerous endocrine pathways affecting mood, libido, fat composition, muscle mass accumulation, germ cell production, and intellectual activity (Tsujimura, 2013).

As men accumulate adipose tissue, levels of free plasma testosterone decline, especially in individuals with morbid obesity (i.e., BMI of 40 or higher; Kley et al., 1980; Wang et al., 2011; Zumoff et al., 1990). Adipose tissue converts testosterone to estradiol, and increased adipose accumulation, particularly in the abdominal region, is associated with changes in the serum testosterone/estrogen ratio. This ratio disturbance can ultimately lead to abnormally high

estradiol and consequently decreased ejaculate quality and fertility (Vermeulen et al., 2002). Obesity is negatively associated with ejaculate quality (Magnusdottir et al., 2005; Palmer et al., 2012; Santi et al., 2024; Sermondade et al., 2013; Sheyab et al., 2011; Wang et al., 2024). In a large sample of 4,513 Chinese men, obesity was associated with decreases in ejaculate volume, total sperm number, and sperm motility (Wang et al., 2024). A meta-analysis of 28 studies investigating the relationship between obesity and ejaculate quality revealed that sperm motility, sperm concentration, total sperm number, and the percentage of morphologically normal sperm were lower among obese men relative to their normal weight peers (Santi et al., 2024).

Sheyab et al. (2011) grouped 2,035 Scottish men undergoing infertility treatment by BMI. Men with a BMI below 18.5 were categorized as underweight, normal weight with a BMI of 18.5-24.99, overweight with a BMI of 25.0-29.99, and obese if they had a BMI of 30 or higher. Participants provided one masturbatory ejaculate sample, each of which was analyzed via a combination of computer-assisted semen analysis (CASA) and manual methods. The results revealed that obese men were especially likely to produce ejaculates with lower volume and fewer morphologically normal spermatozoa.

Female size and ejaculate quality

Other research documents an association between the size of a male's female copulation partner and the quality of his ejaculate. In numerous insect species (and in several nonhuman mammals), for example, the larger the female partner, the greater the number of sperm ejaculated during copulation, as hypothesized given that larger female size indicates greater fecundity (Kelly & Jennions, 2011; Parker, 1970b; Parker et al., 1999; Parker & Pizzari, 2010). Research on dung flies (*Scathophaga stercoraria*) shows that the allocation of sperm upon ejaculation is associated with female size, as oocyte number is positively correlated with female mass, and

reproductive tract dimensions increase with female size. This results in a larger ejaculate (and more sperm), which helps to displace ejaculates deposited by rival males (Parker, 1970b; Parker et al., 1999). In humans, the association between female body size or weight and male ejaculate quality is not clearly established and may vary due to differences in mating systems between humans, insects, and other mammals (Kelly & Jennions, 2011).

Baker and Bellis (1993, 1995) investigated the relationship between female size and ejaculate quality in humans. They collected copulatory ejaculates from 22 heterosexual couples to examine several factors that were hypothesized to be associated with ejaculate quality. These couples provided survey data indicating demographic and relationship dynamic information, measurements of height and weight, and copulatory ejaculates in condoms. Ejaculate quality was assessed via manual sperm count of ejaculates in the condoms delivered to the lab. In committed couples, after accounting for factors that affect sperm numbers (e.g., male abstinence, amount of time the couple had spent together since their last copulation, male body and testis size), the variable most strongly correlated with the number of sperm ejaculated at the couple's next copulation was the weight of the female partner. Although being underweight is associated with decreased fecundity in women, as measured by duration of time to conception, decreased fecundity (in terms of time to conception) also is observed for obese women (Gaskins et al., 2015). Thus, whether and how female fecundity (and sperm allocation) is associated with female body weight is unclear.

The current study

The current study aimed to conceptually replicate (i) the Shayeb et al. (2011) report of an association between ejaculate quality and male BMI (as described previously), and (ii) the association of female weight (i.e. BMI) with ejaculate quality, reported by Baker and Bellis

(1993). We calculated the BMI for each individual within 34 heterosexual committed couples and compared the copulatory ejaculate (produced during penile/vaginal intercourse) parameter values (averaged from three ejaculates) across three categories (normal, overweight, obese) of male BMI and female partner BMI. The parameters of interest for the current analysis were based on those reported by Shayeb et al. (2011): ejaculate volume, sperm concentration, sperm motility, and normal sperm morphology.

Methods

Participants

The current study reports novel analyses of a subset of data from a larger project (see BLINDED FOR REVIEW). Participants were 34 couples, at least one member of whom attended a Midwestern university in the United States that housed the researchers, with participants' ages ranging from 18 to 32 years (M = 21.55; SD = 3.55). The majority (72.2%) of the sample was Caucasian (14.8% was African American, with 13% "other" or did not report). By self-report, male participants had not had a vasectomy or sought infertility treatment, and female participants were not using hormonal contraceptives at the time of data collection. Each member of a couple was required to be between ages 18 and 35 years to control for age-related fertility decline (Dunson et al., 2004) and couples must have reported that they were currently in a committed, heterosexual, sexually active relationship that had been ongoing for at least three months (range = 3-146 months; M = 26.17 months; SD = 27.08).

Measures

Body Mass Index (BMI). BMI was calculated from measurements of height (cm) and weight (kg) for both members of each couple, using a digital scale with a height-measuring rod (Detecto, Webb City, MO, US). To reduce participant anxiety about physical assessments, male

and female participants were measured by researchers of the same sex. BMI was calculated using the formula: BMI = weight / height^2.

Ejaculate quality. Ejaculate quality was assessed using the Semen Quality Analyzer Gold version (SQA-V; Medical Electronic Systems, Los Angeles, CA, US), a fully automated machine that analyzes ejaculates for several clinical measures (see BLINDED FOR REVIEW, for details) that has demonstrated measurement precision and reliability comparable to manual analysis and Computer Assisted Semen Analysis (CASA; Lammers et al., 2014). Note that this contrasts with the manual methods used by Baker and Bellis (1993) to calculate sperm count. Couples contributed three copulatory ejaculates (see below) during 45 days.

Upon arrival at the lab, the twist-tie-sealed condom's entire ejaculate volume (ml) was measured from the volumetric markings on an Ashton pump pipette and then transferred to a specimen container. An aliquot (0.5 mL) of each ejaculate was syringed into a proprietary measurement capillary possessing a square-shaped chamber for the aliquot (Medical Electronic Systems, Los Angeles, CA, US) that was inserted into a chamber in the SQA-V for automatic analysis by its electro-optical technology, signal conversion, and the application of proprietary algorithms (see BLINDED FOR REVIEW for details). The capillary was designed such that it would not affect sperm motility (see Medical Electronic Systems, Los Angeles, CA, US; chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://mes-global.com/wp-content/uploads/2024/07/SQA-Testing-Capillaries2.pdf). The SQA-V estimates 17 ejaculate parameter values (see BLINDED FOR REVIEW): ejaculate volume (mL), sperm concentration (millions per mL), rapid and slow progressive sperm motility (%) (as Shayeb et al. did not make this distinction in their analyses), and normal sperm morphology (%)—defined as the percentage of normal, motile sperm in the sample. It should also be noted that the quantity of progressive

motile sperm can serve as a measure of sperm count, as it is more closely tied to fertility (WHO, 2022) compared to total sperm count (and see Baker & Bellis, 1993). Each parameter was averaged from three copulatory ejaculates per couple.

Procedures

All procedures were approved by the Institutional Review Board of the university where the data were collected. Participants completed several in-person sessions. In the first session, couples were separated, and each member was escorted to a private room to complete several self-report questionnaires related to their romantic relationship dynamics and personal traits (e.g., personality). Researchers collected several anthropometric measurements, such as height and weight, for each member of a couple separately and in different rooms. At the end of the first session, participants received materials required to collect and transport ejaculates for delivery, at several return sessions within 45 days, including three copulatory ejaculates. Couples were instructed not to schedule return sessions while the female partner was menstruating. The materials for collection of each ejaculate included a non-latex, non-spermicidal condom (SKYN brand; Iselin, NJ, US) that male participants would wear during copulation with their partner and for ejaculation during such copulatory sessions, a, plastic twist-tie to seal the ejaculate inside the condom and prevent spillage, a screw-top specimen container (in which used and tied condoms were placed), a biohazard Ziploc bag in which the specimen container would be placed, and aluminum foil in which to wrap the specimen cup to retain the warmth of the sample while being transported to the lab.

Following World Health Organization (WHO) guidelines (see Cooper et al., 2010), participants were instructed to abstain from ejaculating for at least 48 hours (but no longer than seven days) before each session. Participants were asked to copulate with their regular partner in

a private location of their choosing and to ejaculate while the penis was in the vagina and while wearing the provided condom. Following ejaculation and in line with WHO recommendations to increase the quality of samples delivered to labs, participants secured the condom with a plastic twist-tie, placed it into a specimen container, sealed the container, and wrapped it in aluminum foil. The specimen was then transported under the participant's arm (another measure to ensure the ejaculate sample remained at body temperature [37 degrees Celsius] while being transported to the lab to increase the sample's quality upon arrival at the lab. Similarly, all samples had to be delivered to the laboratory within one hour of collection to ensure sperm would still be alive. All participants provided written consent, and each couple received a total of US$210 for their participation (see BLINDED FOR REVIEW for additional details).

Results

Several ejaculate parameters exhibited significant skewness, consistent with previous findings (Handelsman, 2002); thus, non-parametric statistical methods were employed. Descriptive statistics for relevant study variables are displayed in Table 1.

Because of the skewed ejaculate quality variables and the unequal distribution of participants in the BMI categories, we used Kruskal-Wallis (rank sums) *H* tests to investigate differences in ejaculate quality (ejaculate volume, sperm concentration, percentage of progressively motile and morphologically normal sperm) in relation to the men's BMI (normal, overweight, and obese). There were no significant differences in terms of ejaculate volume [$H(2) = 0.588$, $p = 0.745$], sperm concentration [$H(2) = 1.80$, $p = 0.406$], percentage of progressively motile sperm [$H(2) = 0.276$, $p = 0.871$], or percentage of morphologically normal sperm [$H(2) = 0.608$, $p = 0.738$].

To examine the potential association between male and female BMI and ejaculate quality (as part of the Baker and Bellis conceptual replication), BMI was treated as a continuous variable. We entered as predictors BMI (for both sexes), age of participants, and partner's age. Age was included as a covariate as it is negatively associated with fertility (Dunson et al., 2004). Another covariate was relationship length (in months), as BMI increases with relationship length (Averett et al., 2008). Separate models were conducted for the ejaculate quality parameters identified as significant in Shayeb and colleagues' (2011) data (ejaculate volume and percentage of morphologically normal sperm), using these as variables. For the ejaculate volume model, the overall model was significant ($R^2 = 0.29$, $F(4, 49) = 5.04$, $p = 0.002$); however, the only significant predictor was relationship length ($B = 0.031$, $\beta = 0.53$, $SE = 0.01$, $p < 0.001$). For the percentage of morphologically normal sperm, the overall model was not significant ($R^2 = 0.02$, $F = 0.26$, $p = 0.904$).

Discussion

We aimed to confirm Shayeb et al.'s (2011) findings that obese men have lower ejaculate volume and a lower percentage of morphologically normal sperm than their normal weight counterparts. Additionally, we aimed to replicate Baker and Bellis's (1993) findings that men inseminate more sperm and higher-quality ejaculates into larger women. Neither of these findings were replicated in the current research. Copulatory ejaculate quality (ejaculate volume, sperm concentration, percentage of progressively motile and morphologically normal sperm) did not differ across the BMI categories of normal weight, overweight, and obese, either for the male or female partners. Similar results were obtained when BMI (for both sexes) was treated as a continuous variable. The only statistically significant result was that relationship length positively predicted ejaculate volume. This finding may corroborate research indicating that

healthier men are more likely to be in long-term relationships such as marriage (Koball et al., 2010) and that health is positively correlated with ejaculate quality (Jensen et al., 2007, 2009). Ejaculate volume has a weaker association with fertility outcomes and health compared to sperm morphology (Bonde et al., 1998; Jensen et al., 2007). The finding that relationship length, but not sperm morphology, was predictive of ejaculate volume was therefore unexpected. Further research is recommended to clarify the association between relationship length and ejaculate volume.

There are several possible explanations for the null findings regarding BMI. One is that the current investigation was restricted to participants and couples with no history of fertility problems. The current sample may, therefore, be considerably different from the sample of men assessed by Shayeb et al. (2011), who were recruited from a fertility center. The failure to confirm Baker and Bellis's (1993) finding could reflect the hypothesis of an association between female size and copulatory ejaculate quality based on evidence from non-human species. The dynamics involved in copulatory ejaculate quality in humans may differ from those in non-human species, given that Baker and Bellis conducted the only test of this relationship in humans. In addition, methodological differences may account for the mixed findings. Specifically, the sample sizes were different (22 in Baker and Bellis versus 34 in the current study), and there were different numbers of ejaculates per couple (1-27 in Baker and Bellis, three in the current research). In the present study, all couples provided three copulatory ejaculates, which may suggest the importance of a more precise assessment of the relationship between female BMI and ejaculate quality. In addition, this study employed advanced electro-optical technology for semen analysis, whereas Baker and Bellis conducted manual assessments of ejaculates. The inconsistent findings between the current study and the findings of Baker and

Bellis could also indicate that female BMI is not a sufficiently good indicator of female fecundity and other anthropometric traits (or perhaps a combination of traits, such as fluctuating body asymmetry or waist-to-hip ratio; Jasienska et al., 2006; Lai et al., 2024) may be better predictors.

A limitation of this study is the small sample size of 34 couples, which may have resulted in insufficient statistical power. Even for Shayeb et al. (2011), with a sample of over 2,000 men, only the parameters of ejaculate volume and percentage of normal sperm morphology differed significantly between obese and normal weight men, suggesting that male BMI effects on ejaculate quality are small, and a larger sample is necessary to detect such small effects. This may also be the case for female partner BMI effects on ejaculate quality. Performing a post-hoc power analysis using G*Power (Erdfelder et al., 1996), assuming a fixed model linear multiple regression (R^2 deviation from zero) as this would better fit our data, the power was only 10%, and data from 480 couples would be required to achieve 80% power if the only predictors used were male BMI and female partner BMI. Incorporating such a sample size is something that researchers could consider in the future.

In conclusion, we investigated whether copulatory ejaculate quality differed among normal-weight, overweight, and obese men and their female partners. We did not confirm Shayeb et al.'s (2011) findings that ejaculate volume and normal morphology were lower for obese men, and neither did we find evidence consistent with Baker and Bellis's (1993) finding that males inseminate larger females with higher-quality ejaculates. Further research, ideally with larger samples, is required to gain a better understanding of any relationship between male and female partner BMI and ejaculate quality.

Statements and Declarations

Ethical Considerations: This study was approved by the Ethics Committee of Oakland University (Ethics Code: 00000087) on 02/05/2015. All participants provided written informed consent prior to enrollment in the study. This research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki (2002).

Consent to Participate: All participants provided written informed consent prior to participating.

Consent for Publication: Not applicable

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Table 1. Descriptive statistics for BMI and copulatory ejaculate quality variables.

Target variable	Mean	*SD*	Skewness	Kurtosis
Ejaculate volume (ml)	2.56	1.45	2.08	0.68
Sperm concentration (10^6/ml)	85.76	57.47	2.33	-0.06
Progressive sperm motility (10^6)	37.34	36.55	3.30	1.89
Normal sperm morphology (%)	22.80	7.24	0.38	1.93
Body Mass Index (Men)	26.92	4.80	1.71	-0.61
Body Mass Index (Women)	24.28	5.77	4.30	4.43

$n = 34$