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Obesity Appears to Impact Male Fertility by Degrading Overall Semen Quality Rather than Individual Semen Parameters

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Abstract

Obesity has become a well-recognized medical issue. However its exact role in male infertility remains unclear. The objective of the current study was to determine if an increase in BMI is associated with an increase in semen parameter abnormalities and if this relationship was influenced by other patient activities. Charts were reviewed for one hundred and thirty-three male patients who had also undergone a complete initial office face to face interview, as part of an infertility evaluation and a semen analysis. As part of standard patient care, all patients answered a detailed questionnaire regarding demographics, exposures, medical and reproductive history as part of their infertility evaluation. Patients were grouped according to BMI as normal (20 - 24 kg/m^2), overweight (25 - 30 kg/m^2), or obese (>30 kg/m^2). Semen analysis parameters analyzed included: morphology, volume, concentration, percent motility, and agglutination. While some parameters suggested trends, results were similar between the normal, overweight, and obese BMI, for concentration ($P = 0.18$), volume ($P = 0.845$), motility ($P = 0.06$); % Positive agglutination: 12%, 7%, 7% ($P = 0.668$) and % normal morphology ($P = 0.083$). Unlike a number of previous studies, results indicate that there is no statistically significant association between BMI and any of the individual semen parameters tested. Raw data suggested a trend for decreasing concentration with increasing BMI. Further, data also suggested equal numbers of oligospermics in each group. However, when the data looked at globally rather than on the effects on individually parameters (total number of normal motile sperm cells—NMS), functional sperm cells decreased with increasing BMI. None of these factors appeared to be affected by other patient factors. Collectively these data suggest that obesity has a multifactorial effect on male fertility; possibly due to relationships with the hormone cascade, body composition and potentially testis temperature regulation. Further study will be needed to confirm such relationships.

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Keywords

Body Mass Index, Obesity, Semen Analysis, Sperm Morphology

1. Introduction

Obesity is a growing health concern. The Behavioral Risk Factor Surveillance System, in conjunction with the CDC, conducted a national survey in 2000 and found that, the prevalence of obesity (BMI > 30 kg/m^2) was 19.8%, a 61% increase when compared to a similar survey in 1991 [1]. That number has almost doubled again in the last ten years rising to 35.2% [2]. In addition to its well documented devastating effects on overall health, recent studies have described the effects of obesity on fertility in particular. In a study comparing IVF success rates and female obesity, it was shown that a 0.1 unit increase in waist-hip ratio led to a 30% decrease in probability of conception per cycle [3]. As male factor plays a role in up to 40% of couples seeking treatment for infertility [4], it would appear vital to understand any link between male partner obesity and fertility issues in the male partner and how they affect the overall fertility of the couple.

A number of previous studies have described a correlation between obesity and male factor infertility. However, they appear to offer no definitive cause for the relationship. A Danish study by Jensen *et al*. enrolled 1558 young men (mean 19 years old) when they presented for their compulsory physical exam as part of their country's military drafting system [5]. The authors demonstrated decreased sperm counts and concentration (39 million/mL vs. 46 million/mL) in those with an elevated BMI (>25 kg/m^2). Further, a significant difference was detected in certain hormones in the overweight and obese patients as compared with those with a normal BMI. However, no difference in sperm cell morphology was observed. A study by Kort *et al*. looked at semen analysis results in 520 men, using the WHO standards, grouped according to their BMI, and measured the average normal-motile-sperm count (NMS = volume × concentration × % motility × % morphology). Kort concluded that men with high BMI values (>25) present with few normal-motile sperm cells. As discussed later, this study does not separate out the specific semen analysis parameters in the respective BMI groups [6]. Hammoud *et al*., on the other hand, demonstrated an increased incidence of oligosperma with increased BMI [7]. Further, their data suggested decreased levels of progressively motile sperm as BMI increased.

Other studies have attempted to find alternate explanations for how obesity can be detrimental to male fertility by focusing on sexual function. Sallmén *et al*. conducted a survey-based population study focused on couples that had attempted pregnancy in the prior four years. They found a dose-dependent effect of increasing BMI and infertility. The association between BMI and infertility was similar for older and younger men; apparently disproving the theory that erectile dysfunction in older men is a significant factor [8]. Another recent study, by Nguyen and colleagues, demonstrated that BMI had no effect on coital frequency suggesting that decreased libido in overweight men is not a significant factor [9].

From these previous studies there appears to be general agreement that male obesity can affect fertility, yet there appears to be a lack of consensus as to the mechanisms involved. Further, while a number of studies have examined the relationship between BMI and semen parameters or fertility, few if any have attempted to control for confounding factors in the patient's medical history. In the present retrospective study, the male partners' general medical condition, as determined by both a questionnaire and face-to-face interview, was considered as part of the issue of the effects of BMI on semen parameters.

2. Materials and Methods

In the present study, charts were reviewed for all male patients who presented for an infertility consultation and evaluation at the Texas Tech Physicians Center for Fertility and Reproductive Surgery during an 18 month period in 2008-2010. To be included in the study the male partners had to have presented for a face-to-face interview to review their history and record their vital statistics (*i.e.* height and weight) as part of the couple's infertility workup. Patients were excluded if their questionnaire was missing or if they had an otherwise incomplete chart. By default, this excluded any patient who had missing vital statistics (*i.e.* height and weight), which would have prevented the calculation of their BMI and the placement of their data in the proper group. As there can be a significant difference in the performance of the semen evaluation at different laboratories; especially for morphological parameters, only patients who had the analysis performed at this center, a CAP-RELAP facility, were included in the study. A total of 112 charts from the period met all inclusion criteria and were included in the study and data analysis.

The patient intake questionnaire included questions regarding their demographic, medical, surgical and fertility history, as well as a series of questions which allowed the analysis of confounding variables known to be associated with fertility or infertility issues. These included: proven fertility, psychiatric disorders, tobacco use, alcohol use, chemical exposure, genitourinary anomalies, and other medical conditions. Proven fertility for the male partner was defined as pregnancies fathered with either the current or previous partners. Psychiatric disorders included any degree of depression, bipolar disorder or any other psychiatric disorder requiring medical therapy. Further patients were considered to be tobacco and/or alcohol users whether they admitted to light, moderate, or heavy use. Chemical exposures included contact with pesticides, herbicides, and heavy metals, were all considered especially pertinent given the prominent agriculture industry in the study environment. Sexual dysfunction included mainly erectile dysfunction and decreased libido. Genitourinary anomalies included hypospadias and varicocele. Patients were also asked about surgery to correct genitourinary anomalies or for other reasons such as testicular torsion or inguinal hernia or trauma. Other medical problems reviewed included mainly diabetes, hypertension, thyroid disease, autoimmune disease, and cancer.

The BMI for each patient included in the study was calculated from the vital statistics recorded during the patient interview. Patients were grouped according to their BMI as normal (20 - 24 kg/m^2, N = 24), overweight (25 - 30 kg/m^2, N = 43), or obese (>30 kg/m^2, N = 45), as standardized by the World Health Organization [10]. The semen analysis findings were reviewed for patients in each of these groups, with specific attention to morphology, volume, concentration, percent motility, and presence or absence of agglutination, in accordance with World Health Organization (WHO) guidelines [11]. In cases where patients had multiple semen analysis performed, only the first procedure performed in this laboratory was included in the study.

Resulting data were analyzed by analysis of variance (ANOVA) and post-hoc Tukey HSD tests between the groups using the Statistical Package for the Social Sciences software (SPSS ver. 12; Chicago, IL). A *P*-value < 0.05 was considered statistically significant. In addition to analyzing the effects of BMI on single semen parameters, semen parameters for each patient were combined into NMS after the technique of Kort *et al.* [6].

3. Results

The demographic characteristics and confounding variables appeared similar in all three BMI groups and are summarized in **Table 1**. The average ages of individuals in the normal, overweight, and obese groups were 34, 33, and 34 years respectively (*P* = 0.87). The percentage of individuals in each group who had previously fathered at least one pregnancy was calculated as 38%, 33%, 33% (*P* = 0.67). The rates of depression or other

Table 1. Demographic difference of men with normal, overweight and obese BMI seeking infertility treatment.

	BMI			
Variable	Normal (N = 24)	Overweight (N = 43)	Obese (N = 45)	*P*-value
Age (years)	34	33	34	0.87
Tobacco Use (%)	17	26	18	0.77
Alcohol Use (%)	50	58	53	0.74
Psychiatric Issues (%)	13	5	0	0.57
Toxin Exposure (%)	4	0	0	0.17
PFP (%)*	38	33	33	0.87
Sexual Dysfunction (%)	8	7	16	0.8
GUA (%)	0	9	9	0.06
GUS (%)	21	5	16	0.057

*PFP—previously fathered pregnancy; GUA—genitourinary anomalies; GUS—genitourinary surgeries.

psychiatric problems were 13%, 5%, 0% (*P* = 0.57). The subjects had reported rates of tobacco 17%, 26%, 18% (*P* = 0.77), and alcohol use was seen in 50%, 58%, 53% (*P* = 0.74) of patients, which were similar for all three groups. The self-reported rates of sexual dysfunction were 8%, 7%, and 16% between the three groups (P = 0.80). In addition, individuals from each group had similar rates of other medical problems not categorized for this study (38%, 23%, and 31%; *P* = 0.90). Finally, as the study was based in a region that is heavily involved in agriculture and the petroleum industry, patients were asked about toxin exposure. The resulting rates of exposure were minimal and similar between the three group (4%, 0% and 0%; *P* = 0.17). The data did suggest a potential difference (trend) in genitourinary anomalies (0%, 9%, and 9%; *P* = 0.06), and surgeries involving the genitourinary system (21%, 5%, 16%; *P* = 0.057), with the normal BMI group having had the fewest current anomalies but the most corrective surgery. However the p-values did not rise to the level of significance.

While there were some numerical trends in the data sets, there were no statistical differences seen in any of the individual semen parameters examined between the three BMI groups (**Table 2**). The average volume for all three groups fell within the normal range established in this laboratory (2 - 5 mL) and was 3.6 mL, 3.3 mL, and 3.4 mL (*P* = 0.845). While there was what appeared to be a numerical trend toward decreasing sperm concentration with increasing BMI (**Figure 1**), as might be expected there were wide variations in cell counts between patients and this observation was non-significant (*P* = 0.18). Further, there were similar numbers of patients in each group who would be classified as oilgospermic using WHO criteria (*P* = 0.49). While the average percentage of spermatozoa with normal morphology was below WHO Version 3 standard (standard used in lab at time) [11] for individuals classified as having a normal (27.6%) or obese (28.1%) BMI, there was only a trend toward individuals classified as overweight having greater rates of normal sperm (34.1%; *P* = 0.083), A similar trend was seen for motility where only overweight individuals had average motilities in the normal range (52.7%), while both the normal BMI and obese patients had motilities below the normal cutoff (42.3% and 46.0% respectively; *P* = 0.06). Finally, the rates of agglutination were similar in each group (12%, 7%, 7%; *P* = 0.668).

While no single semen characteristic reached significance in this study, when the technique of Kort *et al*. [6] was applied looking for an effect of obesity on the total normal motile sperm cells, there appears to be differences between the groups (**Figure 2**; *P* < 0.032). Men with normal BMI had significantly higher NMS than the obese group with the overweight individuals having an intermediate value between the two.

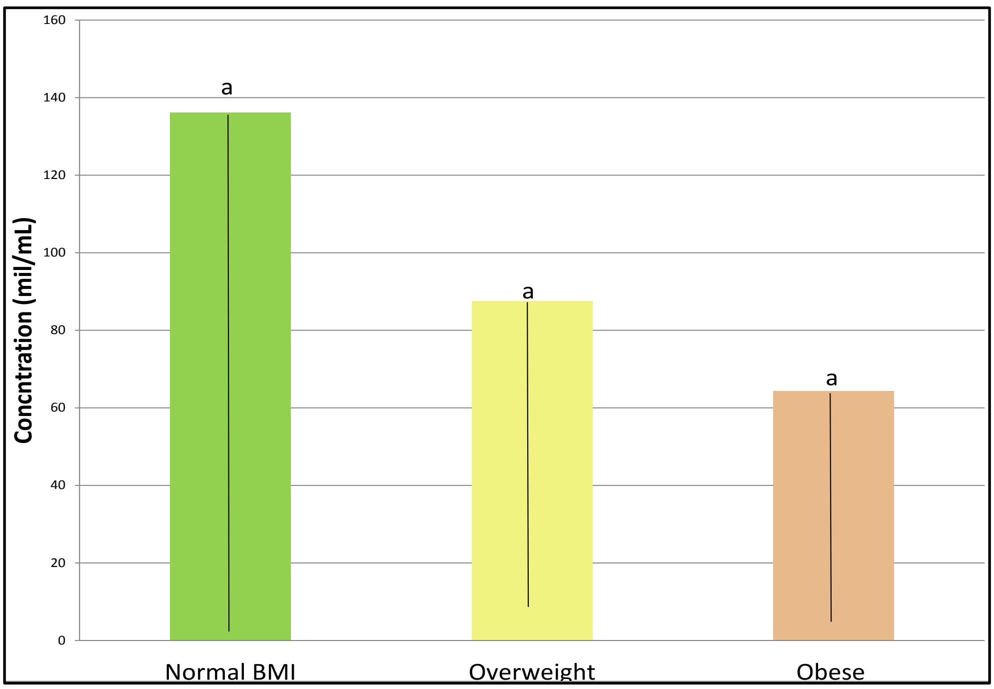

Figure 1. A comparison of sperm cell concentration (millions/mL) from men with a normal, (20 - 24 kg/m^2), overweight (25 - 30 kg/m^2), or obese (>30 kg/m^2) BMIs. Bars with similar subscripts are not significantly different (*P* = 0.18).

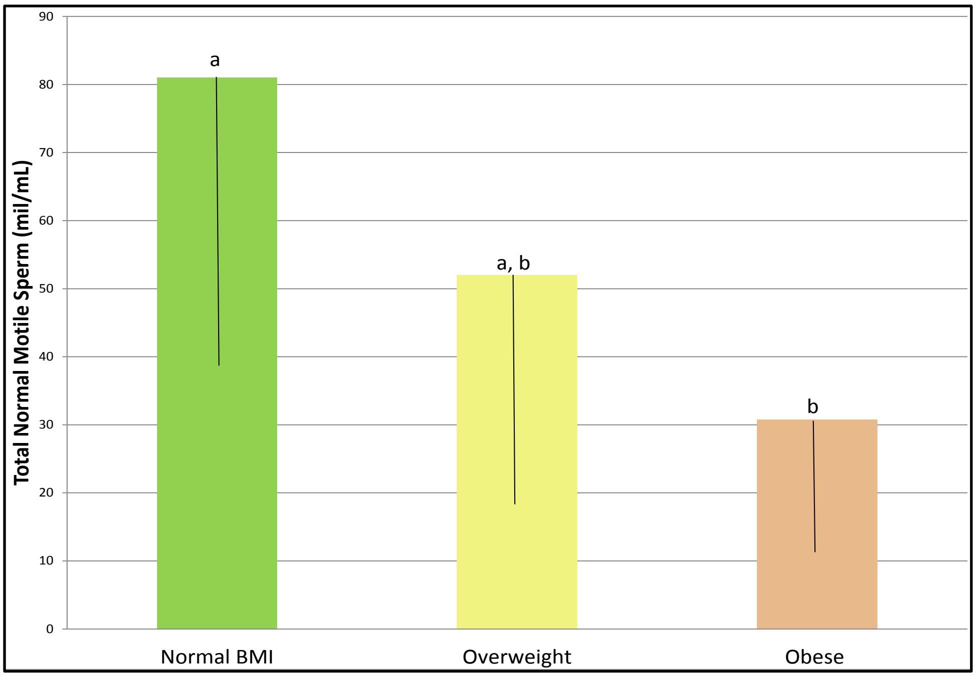

Figure 2. The total normal motile sperm count (NMS; millions/mL) from men with a normal, (20 - 24 kg/m^2), overweight (25 - 30 kg/m^2), or obese (>30 kg/m^2) BMIs. Bars with different subscripts are significantly different ($P < 0.03$).

Table 2. A comparison of four common semen parameters from men with a normal, (20 - 24 kg/m^2), overweight (25 - 30 kg/m^2), or obese (>30 kg/m^2) BMIs.

		BMI			
Variable	Norm value	Normal (N = 24)	Overweight (N = 43)	Obese (N = 45)	*P*-value
Morph*. (%)	>30	27.6	34.1	28.1	0.083
Vol (mL)	>2	3.6	3.3	3.4	0.845
Motility (% forward)	>50	42. 3	52.7	46	0.06
Agg (% with)	none	12	7	7	0.668

*Morph-semen morphology; Vol-volume; Agg-agglutination. All normal values were determined using the WHO guide version 3 which was in use at the time of this study [11].

4. Discussion

In the present study, there appeared to be no direct association between BMI and any single specific semen parameter. While the raw data suggest a numerical correlation for concentration described in previous studies [5] [7] [12]-[16], the stair step decreases seen in the concentration means as BMI increased were not statistically different, This most likely due to the large degree of variability in sperm concentration in the study participants, a normal finding in any population seeking infertility treatment. However, while no single parameter could be found to correlate directly with BMI, the total normal motile sperm count was different between men with normal BMI and those who where obese. These findings appear to confirm the finding of Kort *et al.* [6] and suggest that changes in body chemistry due to increased BMI have a multifactorial effect on sperm production which differ on an individual basis.

If these previously described deceases in concentration are real, they might be explained by the fact that obesity can change the normal hormonal milieu, leading to decreased spermatogenesis. This could explain the Danish study by Jensen *et al.* [5], which while from a much larger population, was limited to individuals of relatively young age. However, the common population seeking infertility treatment is typically older; as seen in the average age of the present study being between 33 - 34 years old. It is Important to note that obesity is thought of as a chronic and progressive disease process and it could take time to manifest effects on the semen profile. This might explain the lack of correlations in the Danish study dealing with only young men, one would assume in generally good physical shape as they were being inducting into military service. However, given the current trend toward obesity at younger ages [10] [15] [16], this may become an issue of concern.

By contrast, the Kort *et al*. [6] study examined volume, concentration, motility and morphology in a combined score. In doing so, it is unclear which specific parameters in the semen analysis profile were more affected by obesity. The same low NMS score could be obtained using different data points, with each having vastly different findings in the semen analysis. The data from the current study also demonstrated a decrease in total number of normal motile cells with increasing BMI, suggesting it might be the combined effects of obesity on the sperm cell structure and function which leads to lower fertility and not the effect on one single parameter alone. Further, it would appear the effects of obesity on male fertility vary widely between individuals, but appears to be the result of changes in normal hormonal patterns. While a number of recent studies have attempted to elucidate these interactions, no definitive relationships have immerged [12]-[14] [17] [18]. This may be due to the complexity of the hormonal arc that leads to normal sperm cell development.

5. Conclusion

While the present study is retrospective and consists of a relatively small number of subjects, it appears to be one of the first to attempt to correct for biases seen in earlier studies by including face-to-face interviews to confirm information recorded on patient questionnaires. While the lack of a direct correlation between any single semen parameter and infertility may be due to the size limitation of the study, the decreased NMS confirms the earlier work of Kort *et al*. [6], and suggests the increased BMI, leads to the well documented changes in overall health status which in turn will potentially lead to changes in reproductive potential [15] [16]. Further work is needed to elucidate the exact mechanism leading to the changes, but with the identified obesity epidemic [3] [10], it can be predicted that more males will have obesity related fertility issues in the future.

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References

[1] Mokdad, A.H., Bowman, B.A., Ford, E.S., *et al.* (2001) The Continuing Epidemics of Obesity and Diabetes in the United States. *JAMA*, **286**, 1195-1200. http://dx.doi.org/10.1001/jama.286.10.1195

[2] Ogden, C.L., Carroll, M.D., Kit, B.K., *et al.* (2012) Prevalence of Obesity in the United States, 2009-2010. NCHS Data Brief, No. 82, National Center for Health Statistics, Hyattsville.

[3] Zaadstra, B.M., Seidell, J.C., Van Noord, P.A., *et al.* (1993) Fat and Female Fecundity: Prospective Study of Effect of Body Fat Distribution on Conception Rates. *British Medical Journal*, **306**, 484-487. http://dx.doi.org/10.1136/bmj.306.6876.484

[4] Guzick, D.S., Overstreet, J.W., Factor-Litvak, P., *et al.* (2001) National Cooperative Reproductive Medicine Network. Sperm Morphology, Motility, and Concentration in Fertile and Infertile Men. *The New England Journal of Medicine*, **345**, 1388-1393. http://dx.doi.org/10.1056/NEJMoa003005

[5] Jensen, T.K., Andersson, A.M., Jørgensen, N., *et al.* (2004) Body Mass Index in Relation to Semen Quality and Reproductive Hormones among 1,558 Danish Men. *Fertility and Sterility*, **82**, 863-870. http://dx.doi.org/10.1016/j.fertnstert.2004.03.056

[6] Kort, H.I., Massey, J.B., Elsner, C.W., *et al.* (2006) Impact of Body Mass Index Values on Sperm Quantity and Quality. *Journal of Andrology*, **27**, 450-452. http://dx.doi.org/10.2164/jandrol.05124

[7] Hammoud, A.O., Wilde, N., Gibson, M., *et al.* (2008) Male Obesity and Alteration in Sperm Parameters. Fertility and Sterility, **90**, 2222-2225.

[8] Sallmén, M., Sandler, D.P., Hoppin, J.A., *et al.* (2006) Reduced Fertility among Overweight and Obese Men. *Epidemiology*, **17**, 520-523. http://dx.doi.org/10.1097/01.ede.0000229953.76862.e5

[9] Nguyen, R.H., Wilcox, A.J., Skjaerven, R., *et al.* (2007) Men's Body Mass Index and Infertility. *Human Reproduction*, **22**, 2488-2493. http://dx.doi.org/10.1093/humrep/dem139

[10] World Health Organization (1999) Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation. WHO Consultation on Obesity, Geneva.

[11] World Health Organization (1999) Laboratory Manual for the Examination of Human Semen and Sperm-Cervical Mucus Interaction. Cambridge University Press, Cambridge.

[12] Pauli, E.M., Legro, R.S., Demers, L.M., *et al.* (2008) Diminished Paternity and Gonadal Function with Increasing Obesity in Men. *Fertility and Sterility*, **90**, 346-351. http://dx.doi.org/10.1016/j.fertnstert.2007.06.046

[13] Winters, S.J., Wang, C., Abdelrahaman, E., *et al.* (2006) Inhibin-B Levels in Healthy Young Adult Men and Prepubertal Boys: Is Obesity the Cause for the Contemporary Decline in Sperm Count Because of Fewer Sertoli Cells? *Journal of Andrology*, **27**, 560-564. http://dx.doi.org/10.2164/jandrol.05193

[14] Aggerholm, A.S., Thulstrup, A.M., Toft, G., *et al.* (2008) Is Overweight a Risk Factor for Reduced Semen Quality and Altered Serum Sex Hormone Profile? *Fertility and Sterility*, **90**, 619-626. http://dx.doi.org/10.1016/j.fertnstert.2007.07.1292

[15] Eisenberg, M.L., Kim, S., Chen, Z., *et al.* (2014) The Relationship between Male BMI and Waist Circumference on Semen Quality: Data from the LIFE Study. *Human Reproduction*, **29**, 193-200. http://dx.doi.org/10.1093/humrep/det428

[16] Schisterman, E.F., Mumford, S.L., Chen, Z., *et al.* (2014) Lipid Concentrations and Semen Quality: The LIFE Study. *Andrology*, **2**, 408-415. http://dx.doi.org/10.1111/j.2047-2927.2014.00198.x

[17] Sánchez-Garrido, M.A., Ruiz-Pino, F., Manfredi-Lozano, M., *et al.* (2014) Obesity-Induced Hypogonadism in the Male: Premature Reproductive Neuroendocrine Senescence and Contribution of Kiss1-Mediated Mechanisms. *Endocrinology*, **155**, 1067-1079. http://dx.doi.org/10.1210/en.2013-1584

[18] Fui, M.N., Dupuis, P. and Grossmann, M. (2014) Lowered Testosterone in Male Obesity: Mechanisms, Morbidity and Management. *Asian Journal of Andrology*, **16**, 223-231. http://dx.doi.org/10.4103/1008-682X.122365