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Correlation between body mass index and semen quality in male infertility patients

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Background/aim: The question of whether body mass index (BMI) affects semen quality and male fertility is controversial. The purpose of this research was to determine whether there is a correlation between BMI and semen analysis parameters.

Materials and methods: A total of 617 male infertility patients were recruited and separated into 3 groups according to BMI values as follows: normal weight group (n = 334), overweight group (n = 220), and obese group (n = 63). Height and weight were measured and a routine semen analysis was performed for all patients.

Results: Significant differences existed in BMI, age, and sperm motility (progressive motility) among the 3 groups. BMI and abstinence period were negatively correlated with sperm motility ($P < 0.05$ and $P < 0.01$), although they did not correlate with semen volume, total sperm number, concentration, and rate of sperm with normal morphology ($P > 0.05$). Abstinence, BMI, and age had a linear correlation with sperm motility ($P < 0.01$) in that order of influence.

Conclusion: Sperm motility, an important semen parameter with respect to male fertility, is reduced in men with increased BMI, and BMI is one of the risk factors that influence semen quality.

Key words: Semen, semen quality, body mass index, obesity, male infertility

1. Introduction

The prevalence of overweight or obese adults is on the rise in Europe, the United States, and China. Based on a body mass index (BMI) of ≥25 kg/m^2, the prevalence of overweight Chinese adults was 29.2% in 2009. The prevalence of obesity in US adults ≥60 years was approximately 37% in 2010. Moreover, it has been estimated that 20%–30% of Europeans in the older age group will be obese in 2015 (1–3). Progressively more domestic and international research is paying close attention to the correlation between weight and reproductive health, especially with respect to the negative effects of being overweight and obese on health. Some studies have reported that obesity and metabolic syndrome have effects on benign prostatic hyperplasia, male hypogonadism, male sexual function and infertility, and prostate cancer. In addition, age and BMI have been identified as risk factors for chronic prostatitis and chronic pelvic pain syndrome (4,5). There is an apparent correlation between BMI, sexual behavior, and sexual health (6). Furthermore, being overweight and obese negatively influences clinical pregnancy and live birth rates after IVF treatment (7,8); however, at present the association between BMI, semen quality, and male fertility is controversial (9–11). Thus, the age, BMI, and semen analysis data of 617 male infertility patients undergoing treatment in our reproductive medical center were summarized in this paper to determine whether or not there is an association and correlation between these factors.

2. Materials and methods

2.1. Subjects

A total of 617 males who sought evaluation at a male infertility clinic between August 2011 and July 2013 were recruited for this study. They had infertility for 4–43 months (average: 14.7 ± 6.3 months). The age range of the patients was 21–67 years (average: 32.0 ± 5.2 years). All patients were healthy; specifically, there were no

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chromosome karyotype abnormalities, Y chromosome microdeletions, cryptorchidism, urogenital system infections, cardiovascular and cerebrovascular diseases, diabetes mellitus, endocrinopathies, or abnormal reproductive hormone levels.

2.2. Methods

Nurses recorded the weights (in kilograms accurate to one decimal place) and heights (in centimeters accurate to one decimal place) of all subjects. Laboratory technicians used Makler counting chambers to perform routine semen analyses, applied Papanicolaou stain to ascertain sperm morphology, and classified the semen quality abnormalities in accordance with the experimental procedures and categories introduced in the Laboratory Manual for the Examination and Processing of Human Semen of the World Health Organization (WHO). The BMI was derived using the following formula: BMI = w/h^2, where w represents weight (kg) and h represents height (m).

2.3. BMI classification, evaluation criteria, and method of grouping the subjects

Based on BMI and the classification and evaluation criteria of the WHO, the 617 patients were separated into 3 groups: normal weight (18.50 kg/m^2 ≤ BMI < 25.00 kg/m^2); overweight (25.00 kg/m^2 ≤ BMI < 30.00 kg/m^2); and obese (BMI ≥ 30 kg/m^2). The BMI values are presented in Table 1.

Table 1. Frequencies of BMI, age, and semen analysis parameters in 3 groups and the statistical tests performed.

Parameters	Statistics	BMI groups (n = 617)			Asymp. sig. value (Kruskal–Wallis H test)
		Normal weight (n = 334)	Overweight (n = 220)	Obese (n = 63)	
BMI	Median	22.85	26.77	31.67	P < 0.01
	5th percentile	19.63	25.17	30.05	
	95th percentile	24.67	29.41	37.49	
	Range	18.94–24.91	25.06–29.98	30.02–42.97	
Age	Median	31.66	31.67	29.90	P < 0.05
	5th percentile	24.91	23.99	23.66	
	95th percentile	39.92	41.89	40.70	
	Range	22.00–67.00	21.00–54.00	22.00–48.00	
Abstinence (days)	Median	4.68	4.85	5.10	P < 0.05
	5th percentile	2.22	2.16	2.19	
	95th percentile	7.79	6.71	6.93	
	Range	2.00–9.00	2.00–7.00	2.00–7.00	
Semen volume (mL)	Median	2.70	2.70	2.40	P < 0.05
	5th percentile	1.88	1.88	1.85	
	95th percentile	4.74	4.63	4.39	
	Range	0.60–8.00	1.80–6.00	1.80–6.20	
Total sperm number (10^6 per ejaculation)	Median	174.96	175.28	195.52	P < 0.05
	5th percentile	57.19	62.78	55.48	
	95th percentile	508.18	523.09	557.28	
	Range	16.15–963.61	43.74–1153.06	45.50–902.12	
Concentration (10^6/mL)	Median	60.24	63.23	69.83	P < 0.05
	5th percentile	22.20	24.26	21.32	
	95th percentile	167.57	167.55	176.31	
	Range	12.03–294.01	16.92–281.81	20.00–258.48	
Progressive motility (%)	Median	37.31	33.99	27.60	P < 0.05
	5th percentile	6.79	6.66	6.47	
	95th percentile	64.39	67.09	57.87	
	Range	1.32–83.59	1.02–87.65	2.00–65.00	
Morphology (normal forms, %)	Median	5.03	4.9	4.47	P < 0.05
	5th percentile	0.03	0.37	0.25	
	95th percentile	12.82	12.02	10.13	
	Range	0.00–17.67	0.00–18.06	0.00–13.37	

2.4. Data processing and statistical methods

BMI values and semen parameters were subjected to a normality test, which indicated an abnormal distribution. Therefore, a nonparametric test was adopted to analyze the data. The median (50th percentile) represented the average level, and the 5th and 95th percentiles represented the top and bottom limitations of 90% of the analyzed data. The Kruskal–Wallis H test was used to compare the statistical difference among the three groups. The Mann–Whitney U test was used to compare the statistical differences between all two-group combinations. The Spearman correlation was used to analyze the correlations between age, BMI, abstinence period, and semen parameters. The statistical differences in prevalence rates were verified by a chi-square test. Whether or not age, BMI, and length of abstinence were factors that influenced semen quality was tested by multiple linear regression. At $P < 0.05$, a statistical difference was considered. Statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL, USA)

3. Results

3.1. Frequency distribution of BMI, age, and semen parameters

Of the 617 study participants, 334, 220, and 63 were classified into the normal weight (54.1%), overweight (35.6%), and obese groups (10.2%), respectively (Table 1).

3.2. Abnormal semen quality classifications in the 3 groups

The prevalence of asthenozoospermia, teratozoospermia, and asthenoteratozoospermia was much higher (12.7%–34.9%) than other abnormal categories; no oligozoospermia (0%) was noted in the 3 groups. The prevalence of abnormal semen quality was 66.9% in the 617 participants. The prevalence of abnormal semen quality in the normal weight, overweight, and obese groups was 65.2%, 66.8%, and 76.1%, respectively. A chi-square test showed no statistical difference among the 3 groups ($P > 0.05$), and no statistical differences existed between each two-group combination ($P > 0.05$). The details are listed in Table 2 and the Figure.

3.3. Comparison of 8 parameters among the 3 groups using the Kruskal–Wallis H test

The Kruskal–Wallis H test indicated that a significant difference in BMI among the 3 groups ($P < 0.01$). Significant differences existed in age and progressive motility ($P < 0.05$); the other 5 parameters were not statistically different ($P > 0.05$). The data are listed in Table 1.

3.4. Comparison of statistical differences between each two-group combination in the 3 groups by using the Mann–Whitney U test

Through a pairwise comparison of the BMI in the 3 groups, we detected statistical differences between all two-group combinations ($P < 0.01$).

Through a pairwise comparison of age in the 3 groups, a statistical difference existed between the normal weight and obese groups and between the overweight and obese groups ($P < 0.05$); however, no statistical difference existed between the normal weight and overweight groups ($P > 0.05$).

With respect to the abstinence period, no statistical differences existed in pairwise comparisons of the 3 groups ($P > 0.05$). There were no statistical differences in semen volume, total sperm number, sperm concentration, and rate of normal sperm morphology using pairwise comparisons in the 3 groups ($P > 0.05$).

The progressive motility of the 3 groups was subjected to pairwise comparisons. There were statistical differences between all two-group comparisons ($P < 0.05$).

3.5. Spearman correlation analysis

BMI was negatively related to sperm motility ($P < 0.05$), while it had no statistical correlation with semen volume,

Table 2. Prevlence of abnormal semen quality in the 3 groups.

BMI group (kg/m^2)	Abnormal rates of semen quality							
	TSN cases (rate)	OL cases (rate)	AS cases (rate)	TE cases (rate)	OLAS cases (rate)	OLTE cases (rate)	ASTE cases (rate)	OLASTE cases (rate)
Normal weight group (n = 334)	0 (0.00%)	0 (0.00%)	85 (25.45%)	64 (19.16%)	1 (0.30%)	1 (0.30%)	65 (19.46%)	2 (0.60%)
Overweight group (n = 220)	0 (0.00%)	0 (0.00%)	58 (26.36%)	45 (20.45%)	0 (0.00%)	0 (0.00%)	44 (20.00%)	0 (0.00%)
Obese group (n = 63)	0 (0%)	0 (0%)	18 (28.57%)	8 (12.70%)	0 (0%)	0 (0%)	22 (34.92%)	0 (0%)

TSN: Total sperm number; OL: oligozoospermia; AS: asthenozoospermia; TE: teratozoospermia; OLAS: oligoasthenozoospermia; OLTE: oligoteratozoospermia; ASTE: asthenoteratozoospermia; OLASTE: oligoasthenoteratozoospermia.

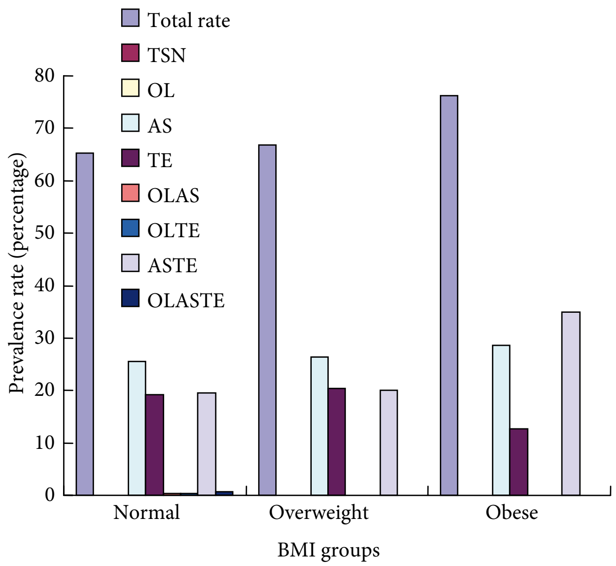

Figure. Prevalence of abnormal semen quality in the 3 groups.

total sperm number, sperm concentration, or rate of normal morphology ($P > 0.05$).

Age was not correlated with semen parameters (semen volume, total sperm number, sperm concentration, sperm motility, and rate of normal morphology; $P > 0.05$).

Period of abstinence was negatively correlated with progressive motility ($P < 0.01$), while no correlations were found between the period of abstinence and semen volume, total sperm number, sperm concentration, motility, and rate of normal morphology ($P > 0.05$).

3.6. Multiple linear regression

BMI, age, and abstinence period were selected as independent variables. Semen volume, total sperm number, sperm concentration, progressive motility, and the rate of normal morphology were chosen as dependent variables. After multiple linear regression analysis was performed, we showed that BMI (x_1), age (x_2), and days of abstinence (x_3) had a significant linear relationship with sperm motility ($y = 48.223 - 0.315 \times x_1 + 0.073 \times x_2 - 1.699 \times x_3$, $P < 0.01$). Abstinence period, BMI, and age influenced sperm motility (in that order). These 3 independent variables had no linear relationship with other semen parameters ($P > 0.05$).

4. Discussion

The prevalence of abnormal semen parameters was 66.9% among 617 infertility clinic patients based on the classification used in the current study. Asthenozoospermia, teratozoospermia, and asthenoteratozoospermia had the highest prevalence, which demonstrated that these 3 types of abnormalities were the main factors that caused semen quality to be reduced among male infertility patients, and also had an impact on male fertility. Furthermore, the prevalence of abnormal semen quality was 65%–76% in the normal weight, overweight, and obese groups. Although no statistical differences existed among the 3 groups, there was a tendency for the prevalence of abnormal semen parameters to increase with an increase in BMI.

In the normal weight, overweight, and obese groups, differences only existed in progressive motility ($P < 0.05$), which was one of the semen parameters evaluated. The median of the progressive motility in the 3 groups decreased as BMI increased. Sekhavat et al. (12) suggested that total sperm number, concentration, and motility in overweight and obese males were significantly lower than in males with a normal BMI. The rate of normal sperm morphology did not differ in any of the groups (12). Nevertheless, Rybar et al. (13) reported that an elevated BMI did not have an influence on basic semen parameters. Mal-Ali et al. (13) concluded that BMI did not have an independent influence on sperm quality parameters based on a multivariable analysis. Our finding that BMI has an impact on sperm motility but no impact on sperm morphology is in agreement with Sekhavat et al. (12). We concur with Rybar et al. (12) and Mal-Ali et al. (13) that BMI does not influence other sperm parameters.

We demonstrated that BMI is negatively correlated with sperm motility; however, it has no correlation with sperm volume, total sperm count, sperm concentration, and rate of normal morphology. Kort et al. (14) showed that BMI is negatively correlated with the total number of sperm cells with normal motility, while statistical differences existed among the BMI groups regarding the total number of sperm cells with normal motility ($P < 0.05$). Sekhavat et al. (15) reported a negative correlation between BMI and semen parameters. According to Paasch et al. (16), only age correlated significantly with sperm parameters, although in patients aged 20–30 years, the total sperm number was negatively correlated with BMI. Håkonsen et al. (11) showed that BMI was inversely associated with sperm concentration, total sperm number, sperm morphology, and sperm motility after adjusting for potential confounding factors. Wogatzky et al. (17) concluded that although a single factor had a minor impact on sperm parameters, the combination of age, BMI, ejaculatory frequency, duration of sexual abstinence, and coffee intake had an adverse effect on sperm motility. MacDonald et al. (18) reported that there was no significant correlation between BMI and semen parameters, with the exception of the rate of normal sperm morphology ($P = 0.024$). Moreover, Hajshafiha et al. (19) showed that the likelihood of oligozoospermia was increased in males with a higher BMI. Obese males were 3.5-fold more likely to have oligozoospermia than males with normal a BMI, while BMI was not noticed to be correlated with mean numeric values of semen parameters, including sperm count, sperm morphology, and sperm motility. The above research conclusions and our results correspond to the viewpoint that BMI is correlated with one or more semen parameters. Pauli et al. (20), Relwani et al. (21), Duits et al. (9), and Mormandi et al. (22) reported that BMI is not significantly correlated with routine semen parameters; however, the possibility of unconventional assessed semen parameters leading to decreased fertility cannot be excluded.

A discrepancy exists not only in independent research regarding the correlation between BMI and semen quality, but also in the following conclusions based on a metaanalysis. MacDonald et al. (18) collected 31 studies in a metaanalysis and concluded that no evidence existed to confirm that there was a relationship between increased BMI and semen parameters, especially with respect to sperm concentration and total sperm number. In 2013, a total of 21 studies and a sample of 13,077 males were included in the metaanalysis conducted by Sermoondade et al. (15). It appeared that there was a J-shaped relationship between BMI categories and risk of oligozoospermia or azoospermia. Compared with normal weight males, the odds ratio was 1.15 (95% confidence interval [CI] = 0.93–1.43) for underweight, 1.11 (95% CI = 1.01–1.21) for overweight, 1.28 (95% CI = 1.06–1.55) for obese, and 2.04 (95% CI = 1.59–2.62) for morbidly obese men. Overweight and obesity were associated with an enhanced prevalence of azoospermia or oligozoospermia (15).

Age and abstinence period affected seminal plasma volume and total sperm output, and also had an influence on total sperm number and sperm concentration based on the WHO criteria. Rybar et al. (13) and Eskandar et al. (23) concluded that there is a negative correlation between age and sperm motility. They also found that age had an impact on sperm concentration, motility, and semen quality. Our research showed that there was no correlation between age and semen volume, total sperm number, concentration, motility, and rate of normal morphology. A significant negative relationship existed between the abstinence period and progressive motility, whereas the abstinence period was not related to other semen parameters. Multiple linear regression analysis showed that abstinence period, BMI, and age were linearly related to sperm progressive motility ($P < 0.01$), in that order. The above 3 independent variables had no linear relationship with other sperm parameters.

We reviewed several studies (11,17,20,24,25) to determine the mechanism by which BMI influenced semen quality and male fertility. This mechanism comprises dysfunction of the hypothalamus-pituitary-gonadal axis, abnormal levels of reproductive and related hormones (INH-B, FSH, LH, E_2, PRL, leptin, T, SHBG, and AMH), dysfunction of male sexual accessory glands (neutral alpha-glucoside enzyme and seminal plasma fructose), and living and dietary habits (coffee intake volume) in overweight or obese patients. An increase in weight or BMI might have no apparent impact or damage on the sperm output from the testes while it influences sperm maturity, motility, or DNA damage. Indeed, BMI, abstinence period, and coffee intake might improve semen quality and enhance male fertility.

In conclusion, there is disagreement as to whether or not BMI has an influence on semen parameters and semen quality; however, our research demonstrated that the most adversely affected susceptible factor among the semen parameters was sperm motility. Indeed, statistical differences existed in sperm motility among the different BMI groups. BMI and abstinence period were negatively related to sperm motility. Sperm motility decreased with an increase in BMI. Therefore, BMI is a risk factor that influences semen quality and reduces male fertility.

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