American Journal of Men's Health
1–8

DOI: 10.1177/1557988318822572
journals.sagepub.com/home/jmh
SAGE

The Negative Impact of Higher Body Mass Index on Sperm Quality and Erectile Function: A Cross-Sectional Study Among Chinese Males of Infertile Couples

Jianzhong Zhang[1], Bin Yang[1,2], Zhonglin Cai[1], Hongjun Li[1], Taoli Han[3], and Ying Wang[3]

Abstract

The objective of the current study was to explore the role of body mass index (BMI) in sperm quality and erectile function in Chinese males of infertile couples. A total of 28 fertility centers in different regions of China were enrolled. Patient data were collected from June 1, 2017, through October 31, 2017. Semen analyses and demographic data were collected and the five-item International Index of Erectile Function (IIEF-5) questionnaire was used to evaluate the erectile function in participants with different BMIs. In total, 3,174 Chinese men of infertile couples with an average age of 33.11 $\pm$ 6.08 years were enrolled. The occurrence of obesity, overweight, normal weight, and underweight were 5.4%, 36.6%, 56.8%, and 1.2%, respectively. In addition to hypertension and diabetes, primary infertility, a longer course of infertility, and chronic prostatitis were risk factors for obesity. Compared with men of normal weight, adjusted odds ratios (ORs) for men with obesity, overweight, and underweight for semen volume $<$2 ml were 2.53 (95% CI [1.61, 3.97]), 1.33 (95% CI [1.09, 1.62]), and 0.84 (95% CI [0.29, 2.43]); for sperm progressive motility (A + B) (%) $<$32, the ORs were 1.60 (95% CI [1.16, 2.22]), 1.30 (95% CI [1.12, 1.51]), and 1.03 (95% CI [0.54, 1.98]); and for IIEF-5 $\leq$ 21, the ORs were 1.52 (95% CI [1.10, 2.10]), 1.11 (95% CI [0.96, 1.30]), and 0.62 (95% CI [0.31, 1.26]), respectively. Obesity was associated with lower semen volume, lower sperm motility, and erectile dysfunction in Chinese males of infertile couples.

Keywords

body mass index, erectile function, obesity, sperm motility, sperm volume

Received August 15, 2018; revised November 9, 2018; accepted December 11, 2018

Obesity is a metabolic disorder in which excessive fat has accumulated and may impair overall health. Body mass index (BMI), which is calculated by dividing body mass by the square of body height, is the indicator usually used to evaluate obesity. Individuals are considered overweight when their BMI is $>$25 kg/m^2 and obese when the BMI is $>$30 kg/m^2. Obesity is associated with multiple diseases and conditions, particularly hypertension, diabetes mellitus, respiratory diseases, osteoarthritis, and certain cancers (Gajalakshmi et al., 2018; Kotsis et al., 2018; Lin et al., 2018; Maccioni et al., 2018; Pozzobon, Ferreira, Blyth, Machado, & Ferreira, 2018; Sharma, Lee, Youssef, Salifu, & McFarlane, 2017). Various studies have focused on the impact of obesity on male infertility, which is

[1]Department of Urology, Peking Union Medical College Hospital, Peking Union Medical College, Chinese Academy of Medical Sciences, Beijing, China
[2]Department of Urology, Affiliated Hospital of the Qingdao University, Qingdao, China
[3]National Institute for Viral Disease Control and Prevention, Chinese Center for Disease Control and Prevention, China

Corresponding Authors:
Bin Yang, Department of Urology, Affiliated Hospital of the Qingdao University, Qingdao 266000, China.
Email: yangbindoc@163.com

Hongjun Li, Department of Urology, Peking Union Medical College Hospital, Peking Union Medical College, Chinese Academy of Medical Sciences, No. 1 Shuaifuyuan, Beijing 100730, China
Email: lihongjun@pumch.cn

associated with sperm quality and erectile function (Liu & Ding, 2017). According to several clinical investigations and animal studies, obesity can negatively interfere with spermatogenesis and sperm maturation by disturbing the balance of sexual hormones, increasing scrotal temperature, inducing chronic inflammation, decreasing Sertoli cell activity, and increasing oxidative stress (Aitken, Gibb, Baker, Drevet, & Gharagozloo, 2016; Cui, Lopez, & Rahmouni, 2017; Divella, De Luca, Abbate, Naglieri, & Daniele, 2016; Garolla et al., 2015; Liu & Ding, 2017). Nevertheless, the mechanisms of how obesity affects male reproduction remain unclear, so more studies are required.

Although various studies have stressed the negative impact of obesity on male reproduction, the role of obesity on semen parameters remains controversial. Several clinical studies have demonstrated reduced sperm motility, concentration, and morphology in obese men of infertile couples (Bieniek et al., 2016; Oliveira et al., 2018; Ramaraju et al., 2018; Taha et al., 2016; Wang, Huang, Du, Yao, & Sun, 2017). However, contradictory or nonsignificant results were also reported in other studies (Bandel et al., 2015; Shayeb, Harrild, Mathers, & Bhattacharya, 2011; Thomsen, Humaidan, Bungum, & Bungum, 2014). Due to the inconsistency of these studies, a meta-analysis was performed by pooling all qualified semen analyses. The results indicated no significant differences in any of the conventional semen parameters except abnormal morphology. Significant heterogeneity existed between the enrolled studies, and many studies did not aggregate in this meta-analysis (Campbell, Lane, Owens, & Bakos, 2015).

Erectile dysfunction (ED) is defined as the persistent inability to attain and maintain an erection sufficient to permit satisfactory sexual performance. Epidemiological data have revealed a high prevalence and incidence of ED worldwide (Feldman, Goldstein, Hatzichristou, Krane, & McKinlay, 1994; Zhang, Yang, Li, & Li, 2017). A cross-sectional study with a relatively large number of survey subjects demonstrated that the prevalence of ED is much higher in men of infertile couples than in the general male population (Yang et al., 2018). ED shares common risk factors with cardiovascular disease, and several reports have demonstrated an association between ED and abnormal BMI (Besiroglu, Otunctemur, & Ozbek, 2015; Binmoammar, Hassounah, Alsaad, Rawaf, & Majeed, 2016; Salonia et al., 2012). However, only a few studies have explored the effects of BMI on the occurrence of ED in men of infertile couples, and the results were inconsistent (Corona et al., 2014; Yu et al., 2017).

In addition to the inconsistency of the effects of BMI on semen parameters and erectile function, knowledge of the association between BMI and sperm quality as well as erectile function in Chinese males of infertile couples is limited. Accordingly, this cross-sectional and clinical study was performed to evaluate this association in a Chinese population.

Materials and Methods

Study Design and Participants

The current cross-sectional and clinical study focused on the male partners of infertile couples who failed to conceive after 1 year of regular intercourse without any contraceptive device. The participating men were recruited from 28 urologic clinics in different regions of China from June 1, 2017, through October 31, 2017. The inclusion criteria of the enrolled participants were (a) men living day to day with their female partners and planning to have a baby; (b) couples failing to conceive after 1 year of unprotected regular intercourse; and (c) men attending urologic clinics for their infertility with semen samples analyzed. The exclusion criteria were (a) men with severe cardiovascular disorders, psychiatric diseases, testicular cancer, or a visible genital malformation; (b) men with factors interfering with sperm quality, such as history of surgery on the vasa deferentia, heat exposure to the testis, testicular trauma, taking antipsychotic or chemotherapeutic drugs, a Y chromosome deletion, varicocele, high semen leukocyte count ($<10^6$/ml), or numerical or structural chromosome abnormalities; and (c) men whose female partners had an abnormality of the reproductive system according to a gynecological examination. Ethical approval for this study was obtained from the Medical Research Ethics Committee of (Peking Union Medical College Hospital, China). Participation was completely voluntary and anonymous. All patients in the current study signed informed consents.

Questionnaire Survey and Semen Analyses

All participants completed a questionnaire covering information including age, height, weight, education level, monthly income, current occupational status, smoking, alcohol drinking, marital status (primary or remarried), type of infertility (primary or secondary), duration of infertility, causes for infertility (male, female, mixed factors or unknown), coexisting diseases (hypertension, diabetes, and chronic prostatitis), the five-item International Index of Erectile Function (IIEF-5), intravaginal ejaculation latency time (IELT), and sexual desire (high, moderate, or low).

Each enrolled male was required to provide a semen sample by masturbating into a sterile plastic container within 3–7 days of sexual abstinence. Semen analyses were carried out strictly according to the 2010 World Health Organization (WHO) manual. Parameters including semen volume, pH, sperm concentration, and the percentages of sperm with rapid motility (Type A motility, %), progressive motility (Type A + B motility, %), and total motility (Type A + B + C motility, %) were recorded.

Statistical Analysis

The study population was classified into four groups according to their BMI: underweight (<18.5 kg/m^2), normal weight (18.5–24.99 kg/m^2), overweight (25–29.99 kg/m^2), and obese (>30 kg/m^2). The χ^2 test was used to compare categorical data across the four BMI groups. Analysis of variance (ANOVA) test was used for normally distributed continuous data and the Kruskal–Wallis test was used for non-normally distributed continuous data. A multivariable binary logistic regression analysis was performed to obtain adjusted odds ratios (ORs) for possible confounding factors associated with an abnormal BMI. A two-tailed p value <.05 was considered statistically significant. The statistical analysis was performed by SPSS 18 for Windows software (SPSS Inc., Chicago, IL, USA).

Results

Basic Characteristics of the Enrolled Participants

A total of 3,174 males of infertile couples with a mean age of 33.11 ± 6.08 years were included in this study. Their basic characteristics are listed in Table 1. The average BMI of the enrolled participants was 24.58 ± 3.07 kg/m^2. Among the 3,174 men, 172 were obese (5.4%), 1,161 were overweight (36.6%), 1,803 (56.8%) were normal, and 38 (1.2%) were underweight. Age tended to increase with a higher BMI ($p < .001$). The incidence of hypertension and diabetes increased in participants with a higher BMI (hypertension: $p < .001$; diabetes: $p = .018$). Interestingly, the BMIs of men with primary infertility, a longer course of infertility, or chronic prostatitis were higher than those without (primary infertility: $p = .002$; longer course of infertility: $p < .001$; chronic prostatitis: $p = .025$). Nonsignificant differences were identified in terms of education level, monthly income, smoking, alcohol drinking, occupation, marital status, or cause of infertility between participants with different BMIs.

Association Between BMI and Semen Parameters

As presented in Tables 2 and 3, semen volume varied in the different BMI groups by ANOVA ($p = .059$). The ORs for men with obesity and overweight for a semen volume <2 ml were 1.49 (95% CI [1.04, 2.11]) and 1.17 (95% CI [0.99, 1.39]), respectively, compared with men of normal weight. After adjusting for age, smoking, alcohol drinking, hypertension, diabetes, chronic prostatitis, and duration of infertility, the ORs for men with obesity and overweight for semen volume <2 ml were significant (obesity: OR 2.53, 95% CI [1.61, 3.97]; overweight: OR 1.33, 95% CI [1.09, 1.62]).

The results indicated significant differences between the different BMI groups in terms of type A motility, progressive motility, and total motility (type A motility: $p < .001$; progressive motility: $p < .001$; and total motility: $p = .045$). The ORs for men with obesity, overweight, and underweight with sperm progressive motility (A + B) (%) <32 were further calculated. The results indicated significant decreases in progressive sperm motility in patients with obesity and overweight (obesity: OR 1.54, 95% CI [1.11, 2.15]; overweight: OR 1.27, 95% CI [1.09, 1.48]). These results remained significant after adjustment (obesity: OR 1.60, 95% CI [1.16, 2.22]; overweight: OR 1.30, 95% CI [1.12, 1.51]).

No significant differences were reported in terms of sperm concentration and pH value (sperm concentration: $p = .886$; pH value: $p = .832$).

Association Between BMI and Sexual Function

The ANOVA results revealed significant differences in the IIEF-5 score between the different BMI groups ($p < .001$; Table 2). Men with obesity and an IIEF-5 score ≤21 compared with men with normal weight had an OR of 1.48 (95% CI [1.07, 2.05]). This result remained significant after adjustment (OR 1.52, 95% CI [1.10, 2.10]).

No significant differences were found in terms of IELT and sexual desire (IELT: $p = .669$; sexual desire value: $p = .105$).

Discussion

Over the past 10 years, many clinical studies have explored the association between semen parameters and obesity; however, the results have been controversial (Bandel et al., 2015; Oliveira et al., 2018; Ramaraju et al., 2018; Shayeb et al., 2011; Taha et al., 2016; Thomsen et al., 2014; Wang et al., 2017). The inconsistency may partly originate from differences in the basic characteristics of the enrolled participants in the different studies, such as ethnicity and the proportion of obese participants. Besides, the study design as well as the inclusion and exclusion criteria also varied among different studies. These differences can result in potential heterogeneity between studies. The huge differences among studies also increased the difficulties for further meta-analyses (Campbell et al., 2015). In the current study, results indicated that obese men of infertile couples were more likely to have a lower semen volume, type A motility, progressive motility (A + B), total motility (A + B + C), and IIEF-5 score than men with normal weight. BMI negatively affected the semen volume, sperm motility, and erectile function in this population.

Table 1. Characteristics of the Enrolled Participants According to Different BMI Groups (n = 3,174).

Parameters	Body mass index (kg/m^2)				p value
	<18.5 (n = 38)	18.5–24.9 (n = 1,803)	25.0–29.9 (n = 1,161)	>30 (n = 172)	
Age (years), mean ± *SD*	29.13 ± 3.93	32.81 ± 6.01	33.72 ± 6.22	33.04 ± 5.73	**.001**
Education level, *n* (%)					.853
University and above	20 (52.64)	921 (51.08)	607 (52.28)	86 (50.00)	
High school	9 (23.68)	461 (25.57)	302 (26.01)	40 (23.26)	
No higher than junior high school	9 (23.68)	421 (23.35)	252 (21.71)	46 (26.74)	
Monthly income (¥), *n* (%)					.073
>20,000	1 (2.63)	76 (4.21)	54 (4.65)	4 (2.33)	
10,001–20,000	5 (13.16)	217 (12.04)	154 (13.26)	16 (9.30)	
5,001–10,000	15 (39.47)	682 (37.83)	401 (34.54)	55 (31.98)	
2,000–5,000	14 (36.84)	681 (37.77)	456 (39.28)	72 (41.86)	
<2,000	3 (7.90)	147 (8.15)	96 (8.27)	25 (14.53)	
Smoking, *n* (%)					.569
No	23 (60.53)	959 (53.19)	631 (54.35)	83 (48.26)	
Yes	15 (39.47)	844 (46.81)	530 (45.65)	89 (51.74)	
Alcohol consumption, *n* (%)					.832
No	28 (73.68)	1,018 (56.46)	669 (57.62)	101 (58.72)	
Yes	10 (26.32)	785 (43.54)	492 (42.38)	71 (41.28)	
Occupation, *n* (%)					.635
Office work	17 (44.74)	762 (42.26)	498 (42.89)	61 (35.47)	
Manual labor	12 (31.58)	763 (42.32)	475 (40.91)	87 (50.58)	
Other	9 (23.68)	278 (15.42)	188 (16.20)	24 (13.95)	
Marital status, *n* (%)					.095
Primary	33 (86.85)	1540 (85.41)	971 (83.63)	141 (81.98)	
Remarried	5 (13.15)	263 (14.57)	190 (16.37)	31 (18.02)	
Medical history, *n* (%)					
Type of infertility					**.002**
Primary	27 (71.05)	1,182 (65.56)	810 (69.77)	130 (75.58)	
Secondary	11 (28.95)	621 (34.42)	351 (30.23)	42 (24.42)	
Duration of infertility (years), *n* (%)					**.001**
≤2	24 (63.15)	882 (48.92)	501 (43.15)	67 (38.95)	
>2	14 (36.85)	921 (51.08)	660 (56.85)	105 (61.05)	
Cause of infertility, *n* (%)					.108
Known	31 (81.58)	1,293 (71.71)	833 (71.75)	143 (83.14)	
Unknown	7 (18.42)	510 (28.29)	328 (28.25)	29 (16.86)	
Hypertension, *n* (%)					**.001**
No	38 (100.00)	1,724 (95.62)	1,071 (92.25)	151 (87.79)	
Yes	0 (0.00)	79 (4.38)	90 (7.75)	21 (12.21)	
Diabetes, *n* (%)					**.018**
No	38 (100.0)	1,756 (97.39)	1,120 (96.47)	163 (94.77)	
Yes	0 (0.00)	47 (2.61)	41 (3.53)	9 (5.23)	
Chronic prostatitis, *n* (%)					**.025**
No	32 (84.21)	1,501 (83.25)	992 (85.44)	153 (88.95)	
Yes	6 (15.79)	302 (16.75)	169 (14.56)	19 (11.05)	

Note. Data are shown as mean ± standard deviation or *n* (%). BMI = body mass index.

As a systemic disorder, obesity is associated with various chronic diseases. In the current study, our results indicated that a higher BMI was associated with older subjects, and higher incidence rates of hypertension and diabetes, which was consistent with most studies that have explored the effects of BMI on male reproduction

Table 2. Semen Analyses and Sexual Function of the Men in Different BMI Groups.

Parameters	Body mass index (kg/m^2)				*p* value
	<18.5 (*n* = 38)	18.5–24.9 (*n* = 1,803)	25.0–29.9 (*n* = 1,161)	>30 (*n* = 172)	
Semen analyses					
Semen volume (ml)	3.53 ± 0.86	3.52 ± 0.85	3.46 ± 0.89	3.36 ± 0.94	.059
Sperm concentration ($\times 10^6$)	35.37 ± 7.78	34.77 ± 8.39	34.66 ± 8.51	34.37 ± 8.34	.886
Type A motility (A) (%)	12.61 ± 4.68	13.13 ± 5.21	11.96 ± 4.35	11.67 ± 5.43	**.001**
Progressive motility (A + B) (%)	29.42 ± 7.64	30.33 ± 7.62	28.44 ± 7.57	28.42 ± 8.10	**.001**
Total motility (A + B + C) (%)	38.88 ± 13.93	38.20 ± 11.01	37.02 ± 12.65	36.91 ± 15.11	**.045**
pH value	7.32 ± 0.65	7.35 ± 0.71	7.33 ± 0.58	7.32 ± 0.61	.832
Sexual function					
IIEF-5	21.39 ± 3.42	21.22 ± 3.93	20.49 ± 4.01	20.47 ± 4.61	**.001**
IELT	4.58 ± 1.24	4.45 ± 1.38	4.44 ± 1.39	4.33 ± 1.48	.669
Sexual desire					.105
Weak	4 (10.53)	157 (8.70)	108 (9.30)	18 (10.47)	
Moderate	25 (65.79)	1,178 (65.34)	780 (67.18)	116 (67.44)	
Strong	9 (23.68)	468 (25.96)	273 (23.52)	38 (22.09)	

Note. Data are shown as mean ± standard deviation or *n* (%). BMI = body mass index; IIEF-5 = five-item International Index of Erectile Function; IELT = intravaginal ejaculation latency time.

Table 3. Association Between Abnormal Semen Parameters or Decreased Sexual Function and BMI in Enrolled Participants.

Parameters and BMI groups	*n*/*N* (%)	Crude odds ratio (95% CI)	*p* value	Adjusted odds ratio (95% CI)	*p* value
Semen volume <2 ml					
<18.5	9/38 (23.68)	0.98 [0.41, 2.15]	1.000	0.84 [0.29, 2.43]	.753
18.5–24.9	432/1,803 (23.96)	Reference	–		
25.0–29.9	313/1,161 (26.96)	1.17 [0.99, 1.39]	.068	1.33 [1.09, 1.62]	**.004**
>30	55/172 (31.98)	1.49 [1.04, 2.11]	**.026**	2.53 [1.61, 3.97]	**.001**
Sperm concentration <15 × 10^6/ml					
<18.5	4/38 (10.52)	0.79 [0.20, 2.25]	.810	0.75 [0.26, 2.14]	.590
18.5–24.9	233/1,803 (12.92)	Reference	–		
25.0–29.9	155/1,161 (13.35)	1.03 [0.83, 1.30]	.738	1.06 [0.85, 1.32]	.597
>30	25/172 (14.53)	1.14 [0.70, 1.80]	.554	1.13 [0.72, 1.79]	.584
Progressive motility (A+B) (%) < 32					
<18.5	19/38 (50.00)	1.03 [0.51, 2.07]	1.000	1.03 [0.54, 1.98]	.912
18.5–24.9	888/1,803 (49.25)	Reference	–		
25.0–29.9	641/1,161 (55.21)	1.27 [1.09, 1.48]	**.002**	1.30 [1.12, 1.51]	**.001**
>30	103/172 (59.89)	1.54 [1.11, 2.15]	**.008**	1.60 [1.16, 2.22]	**.004**
IELT <2 min					
<18.5	4/38 (10.53)	0.74 [0.19, 2.09]	.811	0.76 [0.26, 2.16]	.601
18.5–24.9	248/1,803 (13.75)	Reference	–		
25.0–29.9	163/1,161 (14.04)	1.02 [0.82, 1.27]	.828	0.99 [0.80, 1.23]	.948
>30	29/172 (16.90)	1.27 [0.80, 1.95]	.252	1.24 [0.80, 1.90]	.333
IIEF-5 <22					
<18.5	12/38 (31.58)	0.61 [0.28, 1.26]	.186	0.62 [0.31, 1.26]	.189
18.5–24.9	778/1,803 (43.15)	Reference	–		
25.0–29.9	528/1,161 (45.48)	1.10 [0.94, 1.28]	.225	1.11 [0.96, 1.30]	.155
>30	91/172 (52.91)	1.48 [1.07, 2.05]	**.016**	1.52 [1.10, 2.10]	**.010**

Note. Adjusted odds ratios were obtained after adjusting for age, smoking, alcohol drinking, hypertension, diabetes, chronic prostatitis, and duration of infertility by multivariable binary logistic regression analysis. BMI = body mass index; CI = confidence interval; IIEF-5 = five-item International Index of Erectile Function; IELT = intravaginal ejaculation latency time.

(Haslam & James, 2005). Noticeably, a higher BMI is related to a longer duration of infertility and primary infertility, which usually indicates that infertility status is more difficult to manage for men from infertile couples. In addition, the results also showed a positive association between BMI and the prevalence of chronic prostatitis. Considering the association between obesity and chronic inflammation and the proinflammatory state, inflammation stemming from obesity may affect the lower urinary tract and pelvic muscles, which can result in chronic prostatitis. Contributors to obesity, such as excessive food intake, a lack of physical activity, a sedentary lifestyle, and psychiatric disorders, can also be significant causes for chronic prostatitis. Further investigations are required to explore this association.

Semen analysis results demonstrated that obesity and overweight are associated with lower semen volume and sperm motility in this population. These results are consistent with several clinical investigations and animal studies. Several mechanisms explain the effects of obesity on sperm parameters. First, obesity can induce excessive conversion of androgens to estrogens by increasing aromatase activity, and the subsequent reproductive imbalance impairs semen quality (MacDonald, Herbison, Showell, & Farquhar, 2010). Second, obesity is associated with chronic inflammation and oxidative stress in the male reproductive tract, which may directly impair the testicular tissues and sperm quality (Aitken et al., 2016; Divella et al., 2016). Third, obesity increases scrotal temperature, and exposure to heat impairs sperm (Garolla et al., 2015). In addition, some studies have demonstrated that epigenetic changes in obese men might play a role in impaired sperm quality (Mendelson et al., 2017; Wahl et al., 2017). Besides, decreased erectile function and alienation of spousal affection may also have negative impacts on sperm volumes in obese males. A biopsychosocial model may provide a better theoretical basis.

Noticeably, results indicated no significant decrease in sperm concentration in the current study. One reason was that semen volume decreased further than total sperm count in obese males. Sperm concentration, which was determined by dividing total sperm count by semen volume, may not change if semen volume decreases even more.

According to the existing data, the incidence of ED in men of infertile couples was higher than that in the general male population, which is consistent with a previous study. Besides, results indicate that obese males of infertile couples are more likely to have ED. Although the effects of BMI on ED have been well studied, only a few studies have focused on the erectile function in men of infertile couples. Considering the high prevalence of ED in men of infertile couples, the issue should be a focus. Moreover, IELT and sexual desire were evaluated in this study; however, no significant differences were detected. Androgens are converted to estrogens by the increase of aromatase activity in obese men. Increased levels of estrogens and decreased levels of androgens are associated with a lower sexual desire. This study revealed no significant decrease in sexual desire in obese men of infertile couples. This may have originated from the psychological pressures due to the infertile status of these men, and the percentage of men with high sexual desire in this study was low, which may have influenced the association between sexual desire and BMI.

Several strengths of the current study should be discussed: (a) A large number of overweight and obese men of infertile couples were included in the current study, which reflected the current BMI trends in this population. (b) A larger sample size also enabled adjustment for many potential confounders in the multivariate binary logistic regression analysis. (c) In addition to semen parameters, the IIEF-5, IELT, and sexual desire were evaluated in the current population.

Although a large cohort was included, there were several limitations that should be addressed in the current study: (a) Sperm morphology was not analyzed due to various standards used in the enrolled urologic clinics, which added difficulties during data analyses and interpretation. (b) Hormone levels were not recorded in the current study because of the lack of a standard method to quantify hormone levels in the different diagnostic laboratories across the participating hospitals and centers. (c) Although semen analyses were strictly performed according to the WHO manual, only a single semen sample from each male was obtained in the current study.

Conclusions

Obesity was negatively associated with lower semen volume, lower sperm motility, and ED in Chinese males of infertile couples. Patients with a lower semen volume, lower sperm motility, and ED might benefit from losing weight.

Acknowledgments

The following individuals are acknowledged for their contributions in this study from other 27 urological clinics in different hospitals and institutes across the mainland of China: Peng Xu, Yichao Shi, Jixiu Xu, Lianwen Zheng, Haisong Li, Lianghong Ma, Shenmin Yang, Yong Zhao, Yan Zhang, Qiang Du, Qingjun Chu, Bin Chen, Yan Tan, Xiangru Li, Chaobin Li, Fa Sun, Shumin Deng, Jun Guo, Yanfeng Li, Xiaoqiang Liu, Le Ma, Yanxin Song, Long Tian, Jiahui Wang, Hua Xu, Xinrong Zhang, Huiliang Zhou.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work is supported by the grant from National Natural Science Foundation of China (Grant No. 81671448) and Beijing Natural Science Foundation (Grant No. 7162152).

References

Aitken, R. J., Gibb, Z., Baker, M. A., Drevet, J., & Gharagozloo, P. (2016). Causes and consequences of oxidative stress in spermatozoa. *Reproduction, Fertility, and Development*, *28*(1–2), 1–10. doi:10.1071/rd15325

Bandel, I., Bungum, M., Richtoff, J., Malm, J., Axelsson, J., Pedersen, H. S., … Giwercman, A. (2015). No association between body mass index and sperm DNA integrity. *Human Reproduction (Oxford, England)*, *30*(7), 1704–1713. doi:10.1093/humrep/dev111

Besiroglu, H., Otunctemur, A., & Ozbek, E. (2015). The relationship between metabolic syndrome, its components, and erectile dysfunction: A systematic review and a meta-analysis of observational studies. *The Journal of Sexual Medicine*, *12*(6), 1309–1318. doi:10.1111/jsm.12885

Bieniek, J. M., Kashanian, J. A., Deibert, C. M., Grober, E. D., Lo, K. C., Brannigan, R. E., … Jarvi, K. A. (2016). Influence of increasing body mass index on semen and reproductive hormonal parameters in a multi-institutional cohort of subfertile men. *Fertility and Sterility*, *106*(5), 1070–1075. doi:10.1016/j.fertnstert.2016.06.041

Binmoammar, T. A., Hassounah, S., Alsaad, S., Rawaf, S., & Majeed, A. (2016). The impact of poor glycaemic control on the prevalence of erectile dysfunction in men with type 2 diabetes mellitus: A systematic review. *JRSM Open*, *7*(3), 2054270415622602. doi:10.1177/2054270415622602

Campbell, J. M., Lane, M., Owens, J. A., & Bakos, H. W. (2015). Paternal obesity negatively affects male fertility and assisted reproduction outcomes: A systematic review and meta-analysis. *Reproductive Biomedicine Online*, *31*(5), 593–604. doi:10.1016/j.rbmo.2015.07.012

Corona, G., Rastrelli, G., Filippi, S., Vignozzi, L., Mannucci, E., & Maggi, M. (2014). Erectile dysfunction and central obesity: An Italian perspective. *Asian Journal of Andrology*, *16*(4), 581–591. doi:10.4103/1008-682x.126386

Cui, H., Lopez, M., & Rahmouni, K. (2017). The cellular and molecular bases of leptin and ghrelin resistance in obesity. *Nature Reviews Endocrinology*, *13*(6), 338–351. doi:10.1038/nrendo.2016.222

Divella, R., De Luca, R., Abbate, I., Naglieri, E., & Daniele, A. (2016). Obesity and cancer: The role of adipose tissue and adipo-cytokines-induced chronic inflammation. *Journal of Cancer*, *7*(15), 2346–2359. doi:10.7150/jca.16884

Feldman, H. A., Goldstein, I., Hatzichristou, D. G., Krane, R. J., & McKinlay, J. B. (1994). Impotence and its medical and psychosocial correlates: Results of the Massachusetts Male Aging Study. *The Journal of Urology*, *151*(1), 54–61.

Gajalakshmi, V., Lacey, B., Kanimozhi, V., Sherliker, P., Peto, R., & Lewington, S. (2018). Body-mass index, blood pressure, and cause-specific mortality in India: A prospective cohort study of 500 810 adults. *The Lancet Global health*, *6*(7), e787–e794. doi:10.1016/s2214-109x(18)30267-5

Garolla, A., Torino, M., Miola, P., Caretta, N., Pizzol, D., Menegazzo, M., … Foresta, C. (2015). Twenty-four-hour monitoring of scrotal temperature in obese men and men with a varicocele as a mirror of spermatogenic function. *Human Reproduction*, *30*(5), 1006–1013. doi:10.1093/humrep/dev057

Haslam, D. W., & James, W. P. (2005). Obesity. *Lancet*, *366*(9492), 1197–1209. doi:10.1016/s0140-6736(05)67483-1

Kotsis, V., Tsioufis, K., Antza, C., Seravalle, G., Coca, A., Sierra, C., … Grassi, G. (2018). Obesity and cardiovascular risk: A call for action from the European Society of hypertension working group of obesity, diabetes and the high-risk patient and European Association for the study of obesity: Part B: Obesity-induced cardiovascular disease, early prevention strategies and future research directions. *Journal of Hypertension*, *36*(7), 1441–1455. doi:10.1097/hjh.0000000000001731

Lin, H. H., Wu, C. Y., Wang, C. H., Fu, H., Lonnroth, K., Chang, Y. C., & Huang, Y. T. (2018). Association of obesity, diabetes, and risk of tuberculosis: Two population-based cohorts. *Clinical Infectious Diseases*, *66*(5), 699–705. doi:10.1093/cid/cix852

Liu, Y., & Ding, Z. (2017). Obesity, a serious etiologic factor for male subfertility in modern society. *Reproduction*, *154*(4), R123–R131. doi:10.1530/rep-17-0161

Maccioni, L., Weber, S., Elgizouli, M., Stoehlker, A. S., Geist, I., Peter, H. H., … Nieters, A. (2018). Obesity and risk of respiratory tract infections: Results of an infection-diary based cohort study. *BMC Public Health*, *18*(1), 271. doi:10.1186/s12889-018-5172-8

MacDonald, A. A., Herbison, G. P., Showell, M., & Farquhar, C. M. (2010). The impact of body mass index on semen parameters and reproductive hormones in human males: A systematic review with meta-analysis. *Human Reproduction Update*, *16*(3), 293–311. doi:10.1093/humupd/dmp047

Mendelson, M. M., Marioni, R. E., Joehanes, R., Liu, C., Hedman, A. K., Aslibekyan, S., … Deary, I. J. (2017). Association of body mass index with DNA methylation and gene expression in blood cells and relations to cardiometabolic disease: A Mendelian Randomization approach. *PLoS Medicine*, *14*(1), e1002215. doi:10.1371/journal.pmed.1002215

Oliveira, J. B. A., Petersen, C. G., Mauri, A. L., Vagnini, L. D., Renzi, A., Petersen, B., … Franco, J. G., Jr. (2018). Association between body mass index and sperm quality and sperm DNA integrity. A large population study. *Andrologia*, *50*(3). doi:10.1111/and.12889

Pozzobon, D., Ferreira, P. H., Blyth, F. M., Machado, G. C., & Ferreira, M. L. (2018). Can obesity and physical activity predict outcomes of elective knee or hip surgery due

to osteoarthritis? A meta-analysis of cohort studies. *BMJ Open*, *8*(2), e017689. doi:10.1136/bmjopen-2017-017689

Ramaraju, G. A., Teppala, S., Prathigudupu, K., Kalagara, M., Thota, S., Kota, M., & Cheemakurthi, R. (2018). Association between obesity and sperm quality. *Andrologia*, *50*(3). doi:10.1111/and.12888

Salonia, A., Castagna, G., Sacca, A., Ferrari, M., Capitanio, U., Castiglione, F., … Montorsi, F. (2012). Is erectile dysfunction a reliable proxy of general male health status? The case for the international index of erectile function-erectile function domain. *The Journal of Sexual Medicine*, *9*(10), 2708–2715. doi:10.1111/j.1743-6109.2012.02869.x

Sharma, N., Lee, J., Youssef, I., Salifu, M. O., & McFarlane, S. I. (2017). Obesity, cardiovascular disease and sleep disorders: Insights into the rising epidemic. *Journal of Sleep Disorders & Therapy*, *6*(1), 260. doi:10.4172/2167-0277.1000260

Shayeb, A. G., Harrild, K., Mathers, E., & Bhattacharya, S. (2011). An exploration of the association between male body mass index and semen quality. *Reproductive Biomedicine Online*, *23*(6), 717–723. doi:10.1016/j.rbmo.2011.07.018

Taha, E. A., Sayed, S. K., Gaber, H. D., Abdel Hafez, H. K., Ghandour, N., Zahran, A., & Mostafa, T. (2016). Does being overweight affect seminal variables in fertile men? *Reproductive Biomedicine Online*, *33*(6), 703–708. doi:10.1016/j.rbmo.2016.08.023

Thomsen, L., Humaidan, P., Bungum, L., & Bungum, M. (2014). The impact of male overweight on semen quality and outcome of assisted reproduction. *Asian Journal of Andrology*, *16*(5), 749–754. doi:10.4103/1008-682x.125398

Wahl, S., Drong, A., Lehne, B., Loh, M., Scott, W. R., Kunze, S., … Chambers, J. C. (2017). Epigenome-wide association study of body mass index, and the adverse outcomes of adiposity. *Nature*, *541*(7635), 81–86. doi:10.1038/nature20784

Wang, E. Y., Huang, Y., Du, Q. Y., Yao, G. D., & Sun, Y. P. (2017). Body mass index effects sperm quality: A retrospective study in Northern China. *Asian Journal of Andrology*, *19*(2), 234–237. doi:10.4103/1008-682x.169996

Yang, B., Xu, P., Shi, Y., Xu, J., Zheng, L., Li, H., … Li, H. (2018). Erectile dysfunction and associated risk factors in Chinese males of infertile couples. *The Journal of Sexual Medicine*, *15*(5), 671–677. doi:10.1016/j.jsxm.2018.02.019

Yu, X. H., Zhao, J., Zhang, S. C., Li, J. H., Zheng, J. B., Li, Z., … Zhu, Q. X. (2017). The impact of age, BMI and sex hormone on aging males' symptoms and the international index of erectile function scores. *The Aging Male*, *20*(4), 235–240. doi:10.1080/13685538.2017.1361399

Zhang, X., Yang, B., Li, N., & Li, H. (2017). Prevalence and risk factors for erectile dysfunction in Chinese adult males. *The Journal of Sexual Medicine*, *14*(10), 1201–1208. doi:10.1016/j.jsxm.2017.08.009