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MEN'S BODY MASS INDEX IN RELATION TO EMBRYO QUALITY AND CLINICAL OUTCOMES IN COUPLES UNDERGOING IN VITRO FERTILIZATION

Daniela S. Colaci, M.D., M.Sc.¹, Myriam Afeiche, Ph.D., M.P.H.¹, Audrey J. Gaskins, B.S.E.¹, Diane L. Wright, Ph.D.², Thomas L. Toth, M.D.², Cigdem Tanrikut, M.D.³, Russ Hauser, M.D., M.P.H., Sc.D.^{2,4,5}, and Jorge E. Chavarro, M.D., Sc.D.^{1,4,6}

¹Department of Nutrition, Harvard School of Public Health, Boston, MA

²Vincent Obstetrics and Gynecology, Massachusetts General Hospital and Harvard Medical School, Boston, MA

³Department of Urology, Massachusetts General Hospital and Harvard Medical School, Boston, MA

⁴Department of Epidemiology, Harvard School of Public Health, Boston, MA

⁵Department of Environmental Health, Harvard School of Public Health, Boston, MA

⁶Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA

Abstract

Objective—To evaluate the association between men's body mass index (BMI), early embryo quality and clinical outcomes in couples undergoing in vitro fertilization.

Design—Prospective cohort study.

Setting—Fertility clinic in an academic medical center.

Patients—114 couples that underwent 172 ART cycles.

Interventions—None

Main outcome measure—Fertilization rate, embryo quality, implantation rate, clinical pregnancy rate and live birth rate.

Results—Fertilization rate was higher among obese men than among normal weight men (p-trend=0.04) in conventional IVF cycles. No significant associations were found between men's BMI and the proportion of poor quality embryos on day 3 (p-trend=0.67), slow embryo cleavage rate (p-trend=0.17), or accelerated embryo cleavage rate (p-trend=0.07). Men's BMI was unrelated to positive β -hCG rate (p-trend=0.37), clinical pregnancy rate (p-trend=0.91) or live

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Corresponding author: Daniela S. Colaci, M.D., M.Sc., Department of Nutrition, Harvard School of Public Health, 665 Huntington Ave., Boston, MA 02115 (dcolaci@hsph.harvard.edu).

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birth rate (p-trend =0.42) per embryo transfer. Among couples undergoing ICSI, the odds of live birth in couples with obese male partners was 84% (95% CI 10%–97%) lower than the odds in couples with men with normal BMI (p-trend=0.04).

Conclusion—Our data suggest a possible deleterious effect of male obesity on the odds of having a live birth among couples undergoing ICSI.

Introduction

The effects of overweight and obesity on reproductive health have been studied both in women and men. There is increasing evidence that female obesity has a negative effect on assisted reproductive technology outcomes (1–4). Excessive weight in women undergoing assisted reproductive technologies (ART) have been associated with lower pregnancy rates, lower live birth rates, fewer normally fertilized eggs and the need for higher doses of gonadotrophins (1,2,5,6). Furthermore, couples in which both members are obese are at an increased risk of subfertility (7).

Obesity has also been related to impairments in men's reproductive function. Studies have shown that men's body mass index (BMI) is inversely related to androgens levels and positively related to estrogens levels resulting in a hormonal profile consistent with hypogonadotropic hyperestrogenic hypoandrogenemia (8–10). The higher estrogens levels have a deleterious effect on endogenous gonadotrophin secretion as they interfere with gonadotropin-releasing hormone (GnRH) pulsatility (8,11). In addition, male overweight and obesity have been associated with poorer semen quality (12,13), higher sperm DNA damage (10,14,15) and infertility (16). Nevertheless, the relation between men's BMI and assisted reproductive technologies (ART) outcomes has not been examined extensively. The goal of our study was to evaluate the association of men's BMI with fertilization rate, early embryo quality and clinical outcomes in couples undergoing *in vitro* fertilization.

Materials and methods

Study sample

Women and men presenting for evaluation at the Massachusetts General Hospital (MGH) Fertility Center were invited to participate in the EARTH Study, an ongoing study on environmental factors and fertility (17). Enrollment as a couple is not required for participation. Male partners from couples undergoing ART (both techniques: IVF with conventional insemination and ICSI), aged 18–55 years, and without a history of vasectomy were eligible to be enrolled in the study. Men who enrolled with their female partner and were using their own gametes for ART, had complete information on age and BMI and whose partner had completed at least 1 ART cycle by March 31, 2011 were included in this analysis. Of the 291 men recruited between December 2004 and March 2011, 114 men fulfilled the eligibility criteria. The study was approved by the Human Subject Committees of the Harvard School of Public Health and the MGH, and informed consent was obtained from all participants.

Height and weight were measured at study enrollment by trained research nurses. A lifestyle and medical questionnaire was administered by a trained research nurse to all men who agreed to participate in the study. In addition, men were asked to complete a detailed self-report questionnaire focused on lifestyle factors and medical history.

Female partners of eligible men underwent one of three stimulation protocols: 1) luteal phase GnRH-agonist protocol, 2) GnRH-antagonist protocol, or 3) follicular phase GnRH-agonist/Flare protocol. Briefly, on day 3 of induced menses, treatment with exogenous gonadotropins [FSH (Gonal-F, Follistim, Bravelle)] and/or Human Menopausal

Gonadotropin [hMG (Repronex, Menopur)] was initiated and GnRH agonist or antagonist was continued or started following the usual ovarian stimulation protocols. Human Chorionic Gonadotropin (hCG) was administered 36 hours before oocyte retrieval to trigger ovulation. Oocyte retrieval was performed when transvaginal ultrasound showed 3 dominant follicles (16 mm or greater) and the estradiol level reached at least 500 pg/mL. Blood samples were drawn to assess baseline follicle-stimulating hormone level on the third day of any menstrual cycle prior to the treatment (FSH; Elecsys FSH reagent, Roche Diagnostics). Height and weight were also measured in all women enrolled in the study. In addition, they also completed a food and lifestyle questionnaire.

Embryological assessment

Couples underwent IVF with conventional insemination or IVF with intracytoplasmic sperm injection (ICSI) as clinically indicated. As is the standard practice in ART procedures, nuclear maturity of oocytes was determined before ICSI but not before conventional IVF. Embryologists classified oocytes as germinal vesicle, metaphase I, metaphase II (M2) or degenerated. Fertilized oocytes were classified as normally fertilized if they had two pronuclei or abnormally fertilized otherwise. On day 3, embryos were assessed for quality and classified from 1 (best) to 5 (worst) according to their morphological characteristics. Grade 3, 4 and 5 embryos were considered poor quality. In addition, cleavage rate was assessed by counting the number of cells in the embryo on day 3. Embryos that had 6–8 cells on day 3 were considered to have a normal cleavage rate. Embryos with fewer than 6 cells were considered to be cleaving at a slow rate and embryos with more than 8 cells were considered to be cleaving at an accelerated rate. Day 2 embryo transfers (n=6 couples, n=9 cycles) were excluded from the embryo quality analysis as no information was available for day-3 quality. Complete embryo quality was available in 149 cycles.

Clinical outcomes were assessed among all the couples that initiated a cycle (n=172) and among couples who underwent an embryo transfer (N=158). Positive B-hCG rate was defined as an elevation in β -hCG levels above 6 IU/L after embryo transfer. Clinical pregnancy was defined as the presence of an intrauterine pregnancy confirmed by ultrasound. Finally, live birth was defined as the birth of a neonate on or after 24 weeks gestation.

Statistical analysis

Male and female body mass index (BMI) were calculated from the anthropometric assessment obtained at study entry. Men were divided in 3 categories according to the World Health Organization classification: 18.5–24.9 kg/m² (normal), 25–29.9 kg/m² (overweight) and 30 kg/m² (obese) (18).

We used generalized estimating equations (GEE) logistic regression models in order to take advantage of all the available information while accounting for correlations in outcomes across cycles within the same couple. Three sets of regression models were fit for each of the analyses. The first set of models was fit to assess the crude association between male BMI and the outcomes of interest. The second set of models included additional terms for men's age (centered to the mean: 36 years old), women's age (centered to the mean: 35 years old), women's day 3 FSH level (binary: <10 mIU/ml versus $\geq$ 10 mIU/ml), infertility diagnosis (categorical: female, male, unexplained/other), day of embryo transfer (binary: day 2 or 3 versus day 5) and stimulation protocol (binary: agonist versus antagonist). Finally, the third set of models included all the covariates in the second set of models plus a term for women's BMI (centered to the mean: 23 kg/m²). Per initiated cycle analyses were not adjusted for embryo transfer day to avoid inputting an arbitrary day to those cycles without embryo transfer. Covariates were chosen using prior knowledge based on clinical

relevance and a statistical approach based on change in point estimates. Given the sample size, we prioritized the inclusion of potential confounders and known predictors of the ART outcomes considered to be clinically relevant regardless of statistical significance. None of the variables evaluated as potential confounders (men's race, men's smoking status, abstinence time) were associated with both male BMI and ART outcome and were therefore not included in the final multivariate models. Female age, day 3 FSH, infertility diagnosis and stimulation protocol were included based on their clinical relevance.

We used a test for linear trend where a variable with the median value of each category of male BMI was modeled as a continuous variable. To present crude and adjusted rates for each category of male BMI, we used linear combinations of the regression parameters and centered men's and women's age and BMI at their mean values in all models. Men with normal BMI were considered the reference group. To evaluate whether the association between male BMI and clinical outcomes was modified by couples' characteristics, we added interaction terms between male BMI and female BMI and between male BMI and infertility diagnosis. Similarly, to formally test whether the associations of male BMI with clinical outcomes differed significantly between IVF and ICSI cycles we added cross-product terms between male BMI and an indicator of the cycle type. Whenever this test of heterogeneity was statistically significant, we presented separate results for IVF and ICSI cycles accordingly. Finally, we conducted a sensitivity analysis in which we excluded blastocysts transfer.

We considered that an association was present whenever we found evidence of a statistically significant linear trend at $p < 0.05$. Analysis was performed using Statistical Analysis Software (SAS) version 9.2 (SAS Institute Inc., Cary).

Results

Our study sample consisted of 114 couples who collectively underwent 172 ART cycles for whom complete anthropometric and clinical information was available. Of the 114 couples, 104 had both, at least one M2 oocyte retrieved and at least one embryo transfer. Men's mean age (SD) was 36.5 (5.0) years; the majority was Caucasian (88%) and had never smoked (64%). Men's mean (SD) BMI was 27.3 (4.3) kg/m², and 20% were obese (BMI > 30 kg/m²). Of all the couples, 27% were diagnosed as having primarily male factor infertility and 20% reported undergoing previous IVF/ICSI cycles. The median (25th–75th centile) semen parameter values were: sperm concentration 57 million/mL (29–104 million/mL), progressive sperm motility 41% (24%–62%), normal sperm morphology 5% (3%–7%). Female partners' baseline characteristics and response to ovarian stimulation were similar across all categories of male BMI with the exception of female BMI, which was positively related to their partner's BMI (p -trend=0.001) (Table 1). There were 158 cycles with an embryo transfer: 9 (5.7%) were day 2 embryo transfers, 110 (69.6%) were day 3, and 39 (24.68%) were day 5 embryo transfers. Overall, there were 98 positive B-hCG tests, 85 clinical pregnancies and 69 live births.

Among the 172 initiated cycles, 7 cycles had no M2 oocytes retrieved. Fertilization rate was assessed among the remaining 165 cycles from 108 couples. The overall fertilization rate was not associated with men's BMI (Table 2). While fertilization rate in conventional IVF cycles was higher among obese men than among normal weight men (p -trend=0.04), male BMI was unrelated to fertilization rate in ICSI cycles (p , trend=0.87). However, a test for heterogeneity in the relation between male BMI and fertilization rate by fertilization technique indicated that and found that this relation did not differ significantly by fertilization technique (p , heterogeneity=0.72).

Next, we evaluated the relation of men's BMI with in vitro embryo development and clinical outcomes. We did not find a significant association between men's BMI and the proportion of poor quality embryos on day 3 (p-trend =0.67), slow embryo cleavage rate (p-trend=0.17), or accelerated embryo cleavage rate (p-trend =0.07) (Supplemental Table 1).

Men's BMI was unrelated to positive β -hCG rate (p-trend =0.37), clinical pregnancy rate (p-trend =0.91) or live birth rate (p-trend =0.42) per embryo transfer (Table 3). Further adjustment for women's BMI did not considerably change these estimates. Results were similar when the association was examined per initiated cycle. Furthermore, we evaluated whether the associations between male BMI and clinical outcomes were modified by female BMI, or infertility diagnosis and found no evidence of effect modification by these variables (data not shown). The relation between male BMI and live birth differed significantly between IVF and ICSI cycles (p-heterogeneity=0.04). Among couples undergoing ICSI, the odds of live birth in couples with obese male partners were 84% (95% CI 10%–97%) lower than the odds in couples with male partners with normal BMI (p-trend=0.04) (Table 4). This association persisted after adjustment for semen quality parameters (data not shown). Among couples undergoing conventional IVF, there was a suggestion of higher live birth rates with increasing male BMI that was not statistically significant.

Finally, we conducted a sensitivity analysis in which we excluded all blastocyst transfer cycles. In this analysis, the inverse association between men's BMI and the proportion of accelerated cleavage embryos was slightly more pronounced (p=0.01) than that observed in the entire group (p= 0.07). We did not find significant associations between male BMI and all the other outcomes.

Discussion

The aim of our study was to evaluate whether men's BMI was related to fertilization rate, *in vitro* embryo quality and clinical outcomes in couples undergoing ART. We found that obese men had a higher fertilization rate than lean men in IVF cycles and this relation was unchanged after adjusting for semen quality. No significant associations were found between men's BMI and day-3 embryo quality. Men's BMI was not associated with clinical outcomes among couples undergoing conventional IVF. However, in couples undergoing ICSI cycles, male obesity was related to lower odds of having a live birth.

To the best of our knowledge this is the third study assessing the association between male BMI and IVF/ICSI outcomes and the first prospective study in which these associations were adjusted for the most important female characteristics that are known to have critical effect on the overall outcomes (19–23). Our findings are in agreement with Bakos and colleagues who report no association of male BMI with overall fertilization rate or *in vitro* embryo quality on day 3. They did find, however, a significant reduction of blastocyst development and lower pregnancy rate associated with increasing men's BMI (24). Due to our small sample size of day 5 embryo transfers, we were not able to perform an analysis on blastocyst transfer outcomes. Nevertheless, a recent animal study concluded that male obesity was related to reduced embryo cleavage, decreased development to the stage of blastocyst, lower implantation rate and lower fetal development (25). Contrary to our findings, Keltz and collaborators conducted a retrospective analysis and showed that couples with an overweight or obese man (BMI ≥ 25 kg/m²) undergoing traditional IVF had lower clinical pregnancy rates than couples with a lean man. However, they didn't find this association in ICSI cycles (26). Due to the scarce literature available in this topic, it is difficult to assess correctly the origins of the difference between our findings and Keltz's. Clearly, it is important to examine further the relationship between male obesity and ART outcomes.

We found that among couples undergoing ICSI, those with an obese male partner had significantly lower odds of having a live birth. Semen alterations are usually the main cause for choosing ICSI over traditional IVF and the relationship between men's BMI and semen quality impairment is well established. Therefore, one could speculate that the effect of obesity on clinical outcomes was mediated through semen quality. However, our analysis indicated that the relation of male obesity with live birth rates was independent of sperm parameters.

The literature does not suggest any plausible biological explanation for the significantly higher fertilization rate and the apparently higher live birth rates observed among couples with an obese male partner undergoing conventional IVF cycles. Men's BMI has been previously related to lower total sperm count (10,27), sperm concentration (27,28), sperm motility (12), higher DNA fragmentation (10,14,15,29), and deleterious effects on reproductive hormone levels (30–32), including in our previous publication (10) which included some of the men in this report. Given that available data suggests either a deleterious or null effect of men's BMI on semen quality we would have expected an inverse relation, if any, of male BMI with fertilization and live birth rates. Relying on this evidence and the lack in our data of differences between fertilization rate in IVF and ICSI cycles when testing for heterogeneity, we believe that the higher fertilization and live rates observed could either be a chance finding or due to unmeasured confounding that we were not able to adjust for. Given the paucity of data in this area it is important that future studies examine this association.

A potential limitation of our analysis is the limited sample size to evaluate the association between men's weight and blastocyst development. As is the most frequent practice in the United States, the majority of the couples included in our study underwent day 3 embryo transfers and we were not able to fully examine the impact of male BMI on *in vitro* blastocyst development. Since the embryonic genome is activated after the 4 to 8 cell stage, we may have missed an effect of male BMI on early genome activation (33). Another potential limitation is that, given our limited sample size, we used logistic regression to examine the relationship between male BMI and clinical ART outcomes (thereby modeling the odds of each outcome) instead of regression models for proportions such as log-binomial models. Since all the clinical ART outcomes are common, odds ratios from these models are always further away from the null than risk ratios. Nevertheless, we were careful throughout the manuscript in clearly noting that the results were expressed as odds and odds ratios and not as probabilities or risk ratios precisely to avoid difficulties in the interpretation of the results.

Strengths of our analysis include accurate measurements of male and female BMI and complete prospective information on cycle outcomes for the whole study sample. In addition, as we had complete information on female partners, we were able to adjust for female characteristics that are known to affect overall embryological and clinical outcomes (3–6).

In conclusion, we did not find evidence of associations between men's BMI and early embryo development or clinical outcomes among couples undergoing conventional IVF. Our analysis suggested an inverse relation between men's BMI and live birth among couples undergoing ICSI. Since this study was conducted among couples seeking fertility treatment, it is not possible to generalize the results to the general population or derive conclusions on the effect of men's BMI on natural fertility. Given the paucity of data on the role of men's BMI on ART outcomes, compelling data suggesting a deleterious effect of male obesity on semen quality, recent data on beneficial effects of weight loss on semen quality (32), as well as extensive literature on non-reproductive adverse consequences of obesity (34); general

counseling on the benefits of weight reduction among overweight and obese men should remain the norm for men in couples seeking fertility treatment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Study sample characteristics in relation to men's body mass index (N=114 couples, 172 cycles)

	Male Body Mass Index			
	18.5–24.9 kg/m ²	25–29.9 kg/m ²	≥ 30 kg/m ²	p ^a
Men				
N	38	53	23	
Age	35.9 (4.7)	36.6 (5.2)	37.4 (4.5)	0.50
BMI	22.9 (1.4)	27.7 (1.2)	33.7 (3.1)	<0.001
Smoking Status(%)				0.48
Never Smoker	71	62	57	
Former or Current Smoker	29	38	43	
Race %				0.05
White	81	90	92	
Black	0	4	4	
Asian	16	0	4	
Other	3	6	0	
Semen Analysis (%) ^b				
Sperm concentration <15 million/ml	9 (24%)	18 (47%)	13 (34%)	0.06
Sperm motility < 32%	4 (8%)	15 (28%)	16 (30%)	0.06
Sperm morphology <4%	2 (9%)	6 (26%)	4 (17%)	0.18
Abstinence time (days)	3.0 (2.7)	3.0 (8.2)	2.0 (2.5)	0.79
Prior pregnancies with this or other couple (%)	22	34	50	0.17
Women				
Age	34.5 (2.7)	35.0 (4.0)	36.1 (4.3)	0.25
BMI	23.2 (3.5)	23.2 (3.6)	26.8 (5.4)	<0.001
Day 3 FSH	6.7 (2.1)	6.6 (2.2)	7.4 (2.3)	0.34
Smoking Status (%)				0.50
Never Smoker	79	68	74	
Former or Current Smoker	21	32	26	
Race %				0.52
White	82	88	91	
Black	0	2	0	
Asian	13	4	9	
Other	5	6	0	
Ovarian Stimulation Protocol (%)				0.08
GnRH Agonist -Long Luteal Phase	90	83	70	
GnRH Antagonist	5	9	4	
GnRH Agonist-follicular phase initiation (Flare)	5	8	26	
Total oocyte yield ^c	11 (9–13)	11 (10–12)	10 (8–12)	0.40

	Male Body Mass Index			
	18.5–24.9 kg/m ²	25–29.9 kg/m ²	>= 30 kg/m ²	p ^a
Total M2 yield ^c	9 (8–11)	9 (8–10)	8 (7–10)	0.42
Couple				
Primary etiology of infertility (%)				0.73
Female factor	42	43	52	
Male factor	34	25	22	
Unexplained/Other	24	32	26	
Had any previous infertility evaluation (%)	84	85	83	0.97
Previous IVF or ICSI cycle (%)	16	21	26	0.62
Day of embryo transfer (%)				0.34
Day-2	6	4	10	
Day-3	65	57	76	
Day-5	29	39	14	

Continuous variables are expressed in mean (95% CI)

^aFrom ANOVA for continuous variables and the Chi-square test for categorical variables

^bNormal values for semen parameters were assessed using the World Health Organization Manual. WHO laboratory manual for the examination and processing of human semen. Fifth edition.

^cMean and (95% CI) for total and M2 oocytes.

Table 2

Fertilization rate in relation to men's BMI (N=108 couples, 165 cycles)

	Male Body Mass Index			
	18.5–24.99 kg/m ²	25–29.99 kg/m ²	≥ 30 kg/m ²	p-trend
Total fertilization rate % (95% CI)				
N	52	78	35	
Crude	67 (58–75)	72 (67–76)	71 (62–79)	0.44
Adjusted ^a	68 (58–76)	72 (66–77)	72 (62–80)	0.48
Adjusted + Women BMI ^b	68 (59–76)	72 (66–77)	75 (66–82)	0.28
Fertilization rate - IVF cycles % (95% CI)				
N	23	31	20	
Crude	61 (46–73)	70 (64–76)	77 (68–76) ^c	0.05
Adjusted ^a	59 (42–73)	70 (62–77)	76 (65–84) ^c	0.04
Adjusted + Women BMI ^b	59 (44–73)	69 (60–77)	77 (66–86) ^c	0.04
Fertilization rate - ICSI cycles % (95% CI)				
N	29	47	15	
Crude	72 (63–79)	71 (65–77)	65 (49–78)	0.50
Adjusted ^a	74 (65–80)	73 (66–79)	66 (50–79)	0.37
Adjusted + Women BMI ^b	73 (64–80)	74 (67–80)	71 (56–82)	0.87

^a Mean rates (95% CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis and stimulation protocol^b Mean rates (95% CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol and women's BMI^c p-value <0.05 compared to the reference group (Men's BMI 19–24.99 kg/m²)

Table 3

Odds ratios (95% CI) for clinical outcomes per embryo transfer cycle in relation to men's BMI (N= 172 initiated cycles, 158 cycles with embryo transfer).

	Male Body Mass Index			p-trend
	18.5–24.99 kg/m ²	25–29.99 kg/m ²	>= 30 kg/m ²	
Clinical outcomes per initiated cycle				
N (cycle)	54	80	38	
Positive B-hCG rate				
Adjusted ^a	Ref	0.57 (0.25–1.32)	0.79 (0.28–2.24)	0.51
Adjusted + Women BMI ^b	Ref	0.58 (0.25–1.36)	1.04 (0.31–3.44)	0.78
Clinical pregnancy				
Adjusted ^a	Ref	0.88 (0.41–1.87)	1.08 (0.44–2.66)	0.93
Adjusted + Women BMI ^b	Ref	0.90 (0.42–1.96)	1.53 (0.52–4.52)	0.55
Live birth				
Adjusted ^a	Ref	0.83 (0.40–1.74)	0.72 (0.28–1.82)	0.47
Adjusted + Women BMI ^b	Ref	0.85 (0.40–1.79)	0.91 (0.32–2.60)	0.79
Clinical outcomes per embryo transfer				
N (cycles)	50	73	35	
Positive B-hCG rate				
Adjusted ^c	Ref	0.57 (0.23–1.42)	0.68 (0.24–1.98)	0.37
Adjusted + Women BMI ^d	Ref	0.57 (0.23–1.44)	0.76 (0.23–2.55)	0.47
Clinical pregnancy				
Adjusted ^c	Ref	0.99 (0.44–2.20)	1.07 (0.42–2.67)	0.91
Adjusted + Women BMI ^d	Ref	1.03 (0.45–2.33)	1.31 (0.45–3.80)	0.66
Live birth				
Adjusted ^c	Ref	0.83 (0.37–1.83)	0.69 (0.27–1.73)	0.42
Adjusted + Women BMI ^d	Ref	0.84 (0.38–1.85)	0.79 (0.28–2.21)	0.62

^aOdd ratios (95%CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol.

^bOdd ratios (95%CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol and women's BMI.

^cOdd ratios (95%CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol and embryo transfer day.

^dOdd ratios (95%CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol, embryo transfer day and women's BMI.

Table 4

Odds ratios (95% CI) for clinical outcomes in couples undergoing ART according to fertilization method (conventional IVF and ICSI).

		Male Body Mass Index			
	N cycles	18.5–24.99 kg/m2	25–29.99 kg/m2	>= 30 kg/m2	p-trend
IVF cycles					
Clinical Pregnancy per initiated cycle <i>a,b</i>	74	Ref	0.83 (0.34–2.06)	1.69 (0.52–5.46)	0.38
Live birth per initiated cycle <i>a,b</i>	74	Ref	1.80 (0.58–5.65)	1.84 (0.48–7.06)	0.35
Clinical pregnancy per embryo transfer <i>c,b</i>	72	Ref	0.92 (0.38–2.22)	1.54 (0.47–5.06)	0.51
Live birth per embryo transfer <i>c,b</i>	72	Ref	1.81 (0.59–1.71)	1.63 (0.43–6.16)	0.44
ICSI cycles					
Clinical Pregnancy per initiated cycle <i>b,d</i>	91	Ref	0.57 (0.20–1.63)	0.62 (0.14–2.67)	0.35
Live birth per initiated cycle <i>b,d</i>	91	Ref	0.40 (0.14–1.17)	0.20 (0.04–1.00)	0.03 ^f
Clinical pregnancy per embryo transfer <i>b,e</i>	86	Ref	0.53 (0.16–1.68)	0.53 (0.11–2.55)	0.29
Live birth per embryo transfer <i>b,e</i>	86	Ref	0.40 (0.12–1.37)	0.16 (0.03–0.90) ^f	0.04 ^f

^a 53 Couples initiate an IVF cycle and underwent 74 IVF cycles.

^b Odds ratios (95%CI) adjusted for men's age, women's age, day 3 FSH level, infertility diagnosis, stimulation protocol and women's BMI.

^c 52 couples that underwent 72 embryo transfers among IVF cycles.

^d 55 Couples initiate an ICSI cycle and underwent 91 ICSI cycles.

^e 52 couples that underwent 86 embryo transfers among ICSI cycles.

^f p-value <0.05 compared to the reference group (Men's BMI 19–24.99 kg/m²)