High body mass index and altered androgen hormones are the disruptors of fertility among women undergoing ART

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Research Article

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Abstract

Background: The body mass index (BMI) affects reproduction and pregnancy outcomes. Infertility is defined as the inability to conceive despite having frequent, unprotected sex for at least one year. The inability to have children affects men and women across the globe.

Methods: It was a retrospective study on couples coming for treatment of subfertility in Lahore Institute of Fertility and Endocrinology (LIFE). The institutional ethical review committee approved. Patients are divided into three groups, normal weight (BMI ≤25kg/m²), overweight (26-30 kg/m²), and obese (>30 kg/m²). Data were collected from July 2017 to May 2018. The number of infertile women who underwent assisted fertilization at LIFE was 222.

Results: Two hundred and twenty-two sub-fertile patients were selected. Their ages were between 25-36 years. The mean age was 31 ± 3.91 years. There was a significant relationship between the number of follicles and BMI (p-value=0.03). Outcome parameters are significantly correlated with all groups of BMI. Embryo transfer is insignificantly correlated with BMI. (p-value = 0.07)

Conclusion: According to this study, obesity is associated with poor embryos in obese women with more than 30 BMI. Furthermore, women who were obese might need a higher dose of FSH, and the live birth rate is higher in women with normal BMI.

Introduction

Over the last decade, obesity has turned into one of the leading health challenges of the developed world. Extremes of body mass have proven to have widespread adverse effects on the female reproductive cycle, especially among patients using assisted reproductive technology. [1]

In clinical practice, excessive body mass is measured using the body mass index (BMI), determined by dividing the weight in kilograms by the square of the height in meters. The NICE guidelines divides BMI into the following categories: Healthy (18.5-24.9 kg/m^2), Overweight (25.0-29.9 kg/m^2) and Obese (30.0-39.9 kg/m^2).[2] According to WHO, approximately 26% of women in Pakistan were obese in past years, which gradually increased to 38%. This increase in obesity has led to many health problems that develop among these women and burden the healthcare system. Obesity has been correlated with diminished chances of both natural and assisted contraception and contributes to increased rates of miscarriages, congenital anomalies, and gestational congenital disabilities like spinal cord defects and congenital heart anomalies.[3]

Maternal obesity is also directly related to increased maternal complications such as gestational diabetes, pregnancy-induced hypertension, and pre-eclampsia. Moreover, stillbirth, premature labor, assisted birth, caesarian delivery, and maternal mortality are often linked with obesity.[3] Extremes of BMI result in an adverse intrauterine environment for the developing fetus. Previous studies have directly

linked low birth weight (an indicator of intrauterine growth) and maternal obesity, resulting in significantly higher prenatal and perinatal mortality rates.

Female fertility primarily depends on the ovarian reserve, which refers to the reproductive potential left within the woman's two ovaries based on the number and quality of eggs. While there is a clear link between body mass and adverse reproductive effects involving menstruation disturbance and anovulation, [4] there is no evidence that BMI affects the number or quality of embryos. The uterus may be altered acceptance due to decreased endometrial receptivity, resulting in reduced pregnancy rates.[5–9] However, recent studies had indicated that uterine receptivity might be unimpaired in women with increased BMI when hormonal support and embryo quality were standardized. [10]

According to NICE guidelines published in 2004 regarding the assessment and treatment of infertility, it is recommended that women with a BMI of more than 29 kg/m² have a much higher risk to conceive, and if not ovulating, should be informed that losing weight is likely to increase their chances of conception.[2]

Some studies revealed an adverse effect of obesity on ART, and others suggest similar outcomes in obese and non-obese women.[11] A comprehensive retrospective study of 5019 cycles of in-vitro fertilization revealed that obesity was associated with a longer duration and increased amounts of gonadotrophin stimulation, an increased frequency of cycle cancellation for an inadequate response, and lower oocyte yield.[12] Another study conducted in 2010 indicated that increases in BMI were associated with reduced rates of clinical intrauterine gestation.[12]

The objective of this study was to determine the association between obesity and the quality of embryos. Other studies with varying results show no significant adverse response of obesity on ovarian response during controlled ovarian stimulation in ART cycles. Still, they offer a substantial effect on the quality of oocytes.

This study aims to examine the effect of BMI on ovarian stimulation, oocyte quality, fertilization, and clinical pregnancy outcomes in IVF/ICSI.

Methods And Materials

Study design:

It was a retrospective study on couples coming for treatment of subfertility in Lahore Institute of Fertility and Endocrinology (LIFE). An institutional ethical review committee approved this study of Hameed Latif Hospital.

Physical parameters: They were divided into three groups, normal weight (BMI ≤25kg/m²), overweight (26-30 kg/m²), and obese (>30 kg/m²). Data were collected from July 2017 to May 2018. The number of infertile women who underwent assisted fertilization at LIFE was 222.

Inclusion criteria: The women included in this study were aged between 25-36 years, with tubal factors and unexplained factors as a cause of subfertility.

Exclusion criteria: Women with severe PCO and endometriosis will be excluded from this study. Women with any pelvic pathology were also excluded. Couples with azoospermia and severe oligo-asthenospermia were also excluded.

Preliminary assessment: Preliminary examination was done, including hormonal profile, i.e., FSH (rFSH), prolactin, and E2 (Estradiol- E2) on cycle day 2. Moreover, thyroid profile T3, T4, TSH, and screening tests including hepatitis profile, CBC, and blood sugar were done. In addition, a transvaginal scan (EUB 5500 Hitachi) was done to exclude pelvic pathology. Moreover, antral follicle count and uterine status, endometrial thickness was also measured.

Protocol in ART: Pituitary down-regulation was started during the mid-luteal phase with subcutaneous decapeptide (triptorelin acetate) 0.1mg daily. The stimulation drugs (Gonal F [Merck Serono], Puregone [OBS], and IVF-M, [Galaxy]) were started on cycle days 2-3 in required dosage, and regular monitoring was carried out by ultrasound and serial Estradiol level. The stimulating drugs were either human menopausal gonadotrophins or follicular stimulating hormones.

Recombinant HCG (IVF-C Galaxy) was given at a specific follicular size (18-20mm), and egg retrieval in dosage 5000 or 10000 IU was performed 36 hours later. In addition, embryo transfer was done 3-5 days later.

Data Analysis:

SPSS 25.0 will be used for data analysis; descriptive analysis will be done, i.e., frequencies and percentages of categorical variables, mean standard deviation, and variance for numerical variables. The chi-square test will check the association between BMI and ovarian hyper-stimulation. The level of significance will be 0.05 or 5%.

Results

Two hundred and twenty-two subfertile patients were selected. Their ages were between 25-36 years. The mean age was 31 ± 3.91 years.

The detailed characteristics of subfertile patients are given in Table 1.

Table 1
Demographic and pre-stimulation characteristics. Results are given as mean and standard deviation (Chi-Square test) and hormonal profile given as median and 95% CI (Kruskal Wallis test) P-value > 0.05

Characteristics	**BMI kg/m2**			**p-value**
	21-25	**26-30**	**>30**	
	A	**B**	**C**	
Number of women [n (%)]	73 (32.9)	104 (46.8)	45 (20.3)	
Age (years) (mean ±S.D)	31.10 ± 3.36	31.39 ± 4.05	32.66 ± 4.29	0.42
Base line endocrine parameters [median (95% C.I)]				
FSH mIU/ml	6.40 (6.19-6.94)	6.86 (6.39-7.15)	7.08 (6.51-7.68)	0.38
TSH uIU/ml	1.75 (1.88-2.83)	1.73 (1.95-2.65)	2.06 (1.94-2.71)	0.46
AMH ng/ml	2.90 (2.91-3.64)	2.63 (2.59-3.38)	2.73 (2.44-3.48)	0.21
Prolactin ng/ml	14.76 (14.39-20.21)	15.05 (15.32-24.7)	11.55 (7.03-33.34)	0.09
E2 pg/ml	1 (9.51-22.80)	1 (10.22-25.08)	1 (8.41-35.39)	0.82
Ultrasonography parameters [n (%)] **AFC**				
≤8	44 (60.3)	25 (34.2)	4 (5.5)	
9-12	78 (75)	21 (20.2)	5 (4.8)	0.13
≥13	28 (62.2)	12 (26.7)	5 (11.1)	
Infertility duration (years) (mean ±S.D)	5 ± 2.88	5 ± 3.53	6 ± 4.71	
Infertility type [n (%)]				
Primary infertility	165 (74.3)			0.09
Secondary infertility	57 (25.7)			
Infertility etiology [n (%)]				
Female factor				
Tubal factor	69 (31.1)			0.17
Unexplained factors	80 (36.0)			

Characteristics	BMI kg/m2			p-value
	21-25	26-30	>30	
	A	B	C	
Male factors [n (%)]				
Oligospermia	53 (23.9)			
Azoospermia	20 (9.0)			

Note: FSH, Follicle Stimulating Hormone; AMH, Anti Mullerian Hormone; TSH, Thyroid Stimulating Hormone; E2, Estradiol; AFC, Antral Follicle Count.

As for primary subfertility 34.5% (57) patients were in group A (≤25 kg/m² BMI), whereas 45.5% (75) were in group B (26-29 kg/m² BMI) and 20% (33) were in group C (≥30 kg/m² BMI), with secondary infertility 28.1% (16) belonged to group A, 50.9% (29) were in group B and 21.1% (12) were in group C (p=0.99).

Etiologically, 31.9% (22) women with tubal factor were in group A, where as 50.7% (35) patients were in group B and 17.4% (12) were in group C. In unexplained subfertile patients (n=80) 30.3% (24) belonged to group A, 48.8% (39) were in group B and 21.3% (17) in group C (p=0.17).

Regarding antral follicle count (AFC), 60.3% of patients of group A had less than eight antral follicles as compared to group B and C (p-value=0.13). 75% of patients in group A had 9-12 antral follicle count as compared to group B (20.2%) and group C (4.8%). 62.2% of patients with more than 13 antral follicular count were in group A as compared to group B and C (26.7%, 11.1%) respectively.

As given in Table 2, the mean number of days of stimulation was 12 in group A, 13 in group B, and 15 in group C. Number of days of stimulation was not significantly different in various groups of BMI. (p-value = 0.31). As for the starting dose of stimulatory drugs, 150IU was the mean starting dose in group A, 200IU in group B, and 150IU in group C. Group C has a higher stimulatory drug dose than group A and B.

Table 2
IVF/ICSI stimulation parameters (Decision Day, FSH dose, E2, P4, Endometrium Thickness) For the Kruskal Wallis test with 5% level of significance.

Characteristics	**BMI kg/m2**			**p-value**
	21-25	**26-30**	**>30**	
Decision day (mean ± S.D)	12 ± 1.44	13 ± 1.53	15 ± 1.75	0.31
Total FSH dose (IU) [median (95% C.I)]	1800 (1840-2232)	1975 (2068 -2410)	2200 (1960-2461)	0.24
Serum endocrine level on hCG decision day				
Estradiol E2 [median (95% C.I)]	4300 (3519.02-4095.67)	4300 (3456.03-5995.67)	4510 (2782.89-7103.12)	0.59
Progesterone P4 [median (95% C.I)]	4.63 (4.57-5.39)	4.44 (4.39-5.08)	4.36 (4.29-5.22)	0.64
Endometrium thickness [median (95% C.I)]	10.24 (9.87-10.81)	10 (9.66-10.38)	10.50 (9.52-10.65)	0.63

The endometrial thickness on decision day in groups A, B, and C were not significantly different. Regarding endometrial thickness, the mean thickness was 10.24 in group A, 10 in group B, and 10.5 in group C (p=0.63).

The mean number of follicles in group A was 14, in group B was 15, and in the group, C was 13. There was a significant relationship between the number of follicles and BMI (p-value=0.03).

In Table 3, the number of follicles, eggs retrieved, fertilized eggs, matured embryos, and cleavage rate decreases as BMI increases. Outcome parameters are significantly correlated with all groups of BMI. Embryo transfer is insignificantly correlated with BMI. (p-value = 0.07)

Table 3
Outcome parameters of ART treatment with BMI. Median and 95% CI (Kruskal Wallis test) to check correlation within different groups of BMI (p-value=0.05)

Outcome parameters	BMI kg/m2			p-value
median (95% C.I)	≤25	26-30	> 30	
No. of follicles	14 (13.54-16.21)	15 (15.13-17.56)	13 (11.77-15.13)	B*C 0.03
No. of eggs retrieved	13(12.01-14.86)	12(11.43-13.45)	9(7.79-10.24)	B*C, A*C (0.00)
No. of embryo cleaved	5(5.06-6.88)	6(5.59-7.06)	4(3.79-5.75)	B*C 0.03
No. of mature embryos	10(8.55-14.62)	9(8.86-10.67)	7(6.02-8.24)	B*C, A*C (0.00)
No. of fertilized embryos	7(6.68-8.31)	7(6.62-8.06)	5(4.73-6.73)	B*C, A*C (0.04) (0.03)
No. of transferred embryos	1(1.02-1.35)	1(1.28-1.56)	1(1.09-1.48)	0.07

41.9% (18) clinical pregnancies were in group B compared to group A and group C (30.2%, 27.9%), respectively. 36% (9) of patients who delivered full-term babies were in group A compared to group B, and C. Miscarriage rate was found to be lowest in group A compared to group B and C (Table 4).

Table 4
Pregnancy Outcome with respect to body mass index (BMI)

	BMI kg/ m^2 [n (%)]		
	≤25	26-30	> 30
Negative	50 (32.7)	75 (49)	28 (18.3)
No embryo transferred	10 (38.5)	11 (42.3)	28 (18.3)
Chemical pregnancy	13 (30.2)	18 (41.9)	12 (27.9)
Delivered	9 (36.0)	8 (32.0)	8 (32.0)
Miscarriages	4 (25.0)	9 (56.3)	5 (18.7)

Discussion

This study was conducted at the Lahore Institute of Fertility and Endocrinology, and we compared the incidence of infertility in different groups divided according to their BMI; each of these three groups further underwent investigations, including hormone level assay and transvaginal ultrasonography, to assess their antral follicle count (AFC) and thus their degree of infertility. Two hundred twenty-two women

were selected based on their subfertility. Patients with PCOS and endometriosis were excluded from this study. Most women belong to our research's 26-30 kg/m2 category.

Age is one of the most critical factors that affect embryo quality, and in older patients is probably the main factor that determines the success rate in IVF. [13–15] In the present study, the mean age was 31 ± 3.91 years in obese women and 33 ± 4.29 years in overweight women.

This study revealed no significant association between the type of infertility and increases in body mass index. In contrast, theoretically, any extremes of BMI should have had adverse effects on the fertility of the women.[16–23] Similarly, the duration of infertility was also insignificant, with the mean duration for all three BMI groups to be five years.

For further analysis, we then resorted to the hormone level assay of the patients to determine the basis of their infertility and to see if there was any relation to the BMI. The baseline levels of 5 hormones, namely FSH, TSH, AMH, Prolactin, and E2, were measured. Still, according to our results, there were no significant changes in these hormones with increasing body mass. FSH and TSH levels both had minor increases with increases in BMI. In contrast, AMH levels, often taken as an indicator for ovarian reserve in female patients, had no significant changes between patients with a healthy BMI of 21-25 kg/m² and patients with a BMI exceeding 30 kg/m². This indicates that extremes of body mass do not affect the number or quality of the eggs.

Similarly, there were no significant differences in E2 levels between different body mass groups, but prolactin levels were slightly decreased in patients with a BMI exceeding 30 kg/m². However, as these values still fall within the normal range of prolactin hormone during pregnancy, they are not considered significant.

In obese women, infertile women, anovulation has been the primary cause of infertility. [25] To assess the antral follicle count, transvaginal ultrasonography was also conducted on all patients. Antral follicle counts in all three groups of BMI have no significant difference between each group. In group A the number of AFC was higher than the other two groups. A study shows that BMI and AFC both are inversely related; by increasing the body mass index (BMI), Ovarian volume was decreased. [26]

The requirements of total FSH dose for stimulation increased with increasing the BMI, long period of ovarian stimulation and the chance of follicles development was lower in those patients who were obese, which leads to fewer oocytes.[27–28] Our study shows the same results. Another study suggested that an Inadequate FSH dose may prevent the patient from hyperstimulation. Later on, it concluded that increasing the FSH dose may lead to better oocytes yield and pregnancy rate. [29]

Different studies showed that obesity correlates with severe reproductive outcomes, including anovulation, infertility, and poor response to ART procedures.[30–31] Many factors like hormonal profile, endometrial thickness, oocyte quality and number, and embryo transfer do not affect obesity. Another study described that endometrial thickness had a significant role in implantation and pregnancy

outcomes in obese women. The pregnancy rate may be increased if endometrium thickness was average and lower the miscarriage rates and pregnancy-related problems.[32] Our results show insignificant association in endometrial thickness regarding BMI, and the number of follicles counted during decision day ranged from 13-15 in all three groups, which are within normal ranges.

According to a study, there was a significant association between obese women and their embryo quality. Compared to women with normal BMI, the embryo quality was poor in obese patients. Basically, in IVF cycles, the primary outcome was not the embryo quality. Only a single study showed the oocyte grading system to check the oocyte quality. [17] It was expected that an increase in body mass would have affected the quality of the embryo themselves and contributed to an adverse environment for pregnancy. However, our study indicates no significant association between a higher BMI and the number or quality of oocytes.

Sperm quality was also another factor that is responsible for embryo quality. Nevertheless, another study showed no association between different groups of BMI patients with any malefactor, and only 13% of patients present who had ICSI procedure; according to previous studies, the embryo structure was also dependent on oocyte quality and blastomere, cleavage rate was restricted to the effect of sperm. [33] However, obesity affects the pregnancy by creating an adverse environment for the fetus, leading to low birth weight and other pregnancy complications. Hence all obese patients are counseled to reduce their body weight and maintain a healthy lifestyle to minimize complications.

Declarations

Conflict of Interest:

The authors declared no conflict of interest.

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References

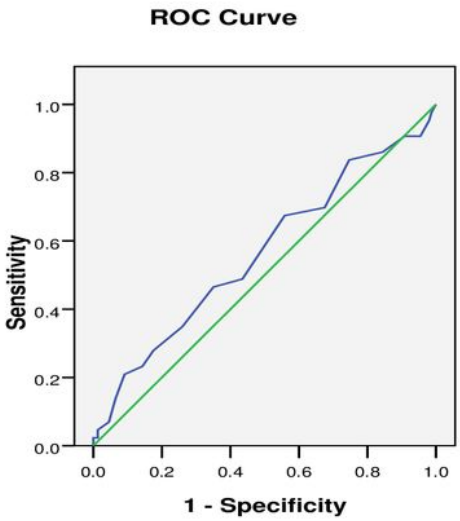
1. (Infertility prevalence) News medical https:// www-medical-net>health.
2. National Institute for Clinical Excellence Fertility: assessment and treatment for people with fertility problems: clinical guideline, February 2004
3. Balen AH, Conway GS, Kaltsas G, Techatrasak K, Manning PJ, West C, Jacobs HS. Polycystic ovary syndrome: the spectrum of the disorder in 1741 patients. Hum Reprod. 1995 Aug;10(8):2107–11.

4. J. X. Wang, M. Davies, and R. J. Norman, "Body mass and probability of pregnancy during assisted reproduction treatment: a retrospective study," British Medical Journal, vol. 321, no. 7272, pp. 1320–1321, 2000.
5. B. Luke, M. B. Brown, J. E. Stern, S. A. Missmer, V. Y. Fujimoto, and R. Leach, "Female obesity adversely affects assisted reproductive technology (ART) pregnancy and live birth rates," Human Reproduction, vol. 26, no. 1, pp. 245–252, 2011.
6. J. Bellver, Y. Ayllón, M. Ferrando et al., "Female obesity impairs in vitro fertilization outcome without affecting embryo quality," Fertility and Sterility, vol. 93, no. 2, pp. 447–454, 2010
7. E. C. A. M. van Swieten, L. van der Leeuw-Harmsen, E. A. Badings, and P. J. Q. van der Linden, "Obesity and clomiphene challenge test as predictors of outcome of in vitro fertilization and intracytoplasmic sperm injection," Gynecologic and Obstetric Investigation, vol. 59, no. 4, pp. 220–224, 2005
8. B. Vural, K. Sofuoglu, E. Caliskan et al., "Predictors of intracytoplasmic sperm injection (ICSI) outcome in couples with and without male factor infertility," Clinical and Experimental Obstetrics and Gynecology, vol. 32, no. 3, pp. 158–162, 2005.
9. S. Shen, A. Khabani, N. Klein, and D. Battaglia, "Statistical analysis of factors affecting fertilization rates and clinical outcome associated with intracytoplasmic sperm injection," Fertility and Sterility, vol. 79, no. 2, pp. 355–360, 2003.
10. D. Hamilton-Fairley, D. Kiddy, H. Watson, C. Paterson, and S. Franks, "Association of moderate obesity with a poor pregnancy outcome in women with polycystic ovary syndrome treated with low dose gonadotrophin," British Journal of Obstetrics and Gynaecology, vol. 99, no. 2, pp. 128–131, 1992
11. Fedorcsak P, Dale PO, Storeng R, Ertzeid G, Bjercke D, Oldereid N, et al. Impact of overweight and underweight on assisted reproduction treatment. Hum Reprod 2004; 19: 2523–2528.
12. Dechaud H, Anahory T, Reyftmann L, Loup V, Hamamah S, Hedon B. Obesity does not adversely affect results in patients who are undergoing in vitro fertilization and embryo transfer. Eur J Obstet Gynecol Reprod Biol. 2006 Jul;127(1):88–93.
13. Roseboom TJ, Vermeiden JP, Schoute E et al. 1995 The probability of pregnancy after embryo transfer is affected by the age of the patient, cause of infertility, number of embryos transferred and the average morphology score, as revealed by multiple logistic regression analysis. Human Reproduction 10, 3035–3041.
14. Lee TH, Chen CD, Tsai YY et al. 2006 Embryo quality is more important for younger women whereas age is more important for older women with regard to in vitro fertilization outcome and multiple pregnancy. Fertility and Sterility 86, 64–69.
15. Chuang CC, Chen CD, Chao KH et al. 2003 Age is a better predictor of pregnancy potential than basal follicle-stimulating hormone levels in women undergoing in vitro fertilization. Fertility and Sterility 79, 63–68.
16. Fedorcsak P, Dale PO, Storeng R et al. 2004 Impact of overweight and underweight on assisted reproduction treatment. Human Reproduction 19, 2523–2528.

17. Wittemer C, Ohl J, Bailly M et al. 2000 Does body mass index of infertile women have an impact on IVF procedure and outcome? Journal of Assisted Reproduction and Genetics 17, 547–552.
18. Loveland JB, McClamrock HD, Malinow AM, Sharara FI 2001 Increased body mass index has a deleterious effect on in-vitro fertilization outcome. Journal of Assisted Reproduction and Genetics 18, 382–386.
19. Spandorfer SD, Kump L, Goldschlag D et al. 2004 Obesity and invitro fertilization: negative influences on outcome. Journal of Reproductive Medicine 49, 973–977.
20. Lintsen AM, Pasker-de Jong PC, de Boer EJ et al. 2005 Effects of subfertility cause, smoking and body weight on the success rate of IVF. Human Reproduction 20, 1867–1875.
21. Vanhoutte L, De Sutter P, Van der Elst J, Dhont M 2005 Clinical benefit of metaphase I oocytes. Reproductive Biology and Endocrinology 3, 71.
22. Dokras A, Baredziak L, Blaine J et al. 2006 Obstetric outcomes after in vitro fertilization in obese and morbidly obese women. Obstetrics and Gynecology 108, 61–69.
23. Ku SY, Kim SD, Jee BC et al. 2006 Clinical efficacy of body mass index as predictor of in vitro fertilization and embryo transfer outcomes. Journal of Korean Medical Science 21, 300–303.
24. Un known
25. Norman RJ, Noakes M, Wu R. Improving reproductive performance in overweight/obese women with effective weight management. Hum Reprod Update. 2004;10:267–80.
26. Zaidi S, Usmani A, Shokh IS, Alam SE. Ovarian reserve and BMI between fertile and subfertile women. J Coll Physicians Surg Pak. 2009 Jan;19(1):21–4. doi:01.2009/JCPSP.2124. PubMed PMID: 19149975.
27. Frattarelli JL, Kodama CL (2004) Impact of body mass index on in vitro fertilization outcomes. J Assist Reprod Genet 21: 211±215. PMID: 15526976
28. Fedorcsak P, Dale PO, Storeng R, Ertzeid G, Bjercke S, Oldereid N, Omland AK, Abyholm T, Tanbo T (2004) Impact of overweight and underweight on assisted reproduction treatment. Hum Reprod 19:2523±2528. doi: 10.1093/humrep/deh485; deh485 [pii]. PMID: 15319380
29. Steward RG, Lan L, Shah AA, Yeh JS, Price TM, Goldfarb JM, Muasher SJ (2014) Oocyte number as a predictor for ovarian hyperstimulation syndrome and live birth: an analysis of 256,381 in vitro fertilization cycles. Fertil Steril 101: 967±973. S0015-0282(13)03458-4 [pii];doi: 10.1016/j.fertnstert.2013.12. 026 PMID: 24462057
30. Davies MJ 2006 Evidence for effects of weight on reproduction in women. Reproductive BioMedicine Online 12, 552–561.
31. Redman LM 2006 Physical activity and its effects on reproduction. Reproductive BioMedicine Online 12, 579–586.
32. Jungheim ES, Lanzendorf SE, Odem RR, Moley KH, Chang AS, Ratts VS. Morbid obesity is associated with lower clinical pregnancy rates after *in vitro* fertilization in women with the polycystic ovarian syndrome. Fertil Steril. 2009;92:256–61

33. Host E, Lindenberg S, Ernst E, Christensen F 1999 Sperm morphology and IVF: embryo quality in relation to sperm morphology following the WHO and Kruger's strict criteria. Acta Obstetricia et Gynecologica Scandinavica 78, 526–529.

Figures



Area under the curve = 0.56

Standard error = 0.05

p-value = 0.20

C.I 95% (lower-upper) = (0.46-0.66)

Cutoff value = 24.50

Sensitivity = 0.83

Specificity = 0.74

Figure 1

Body mass index and pregnancy outcomes.