Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Non-linear threshold association between female body mass index and live birth after intrauterine insemination: a retrospective cohort study

Xiaowan Wang
Northwest Women's and Children's Hospital
Xiaofang Li
Northwest Women's and Children's Hospital
Wenhao Shi
swihao@yeah.net

Northwest Women's and Children's Hospital

Research Article

Keywords: BMI, intrauterine insemination, live birth rate, non-linear relationship, threshold effect

Posted Date: May 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9496249/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background: Evidence regarding the influence of female body mass index (BMI) on intrauterine insemination (IUI) outcomes remains inconsistent, potentially due to heterogeneous cutoff values, inclusion criteria, outcome definitions, or neglect of nonlinear relationships. This study aimed to evaluate the association between female BMI and live birth rate (LBR) following the first IUI cycle, with particular emphasis on characterizing potential nonlinear patterns.

Methods: This retrospective cohort study included 5,651 women undergoing their first IUI cycle. Female BMI was analyzed both as a continuous and a categorical variable, with detailed exploration of nonlinear effects. The primary outcome was LBR; secondary outcomes included biochemical pregnancy, clinical pregnancy, biochemical pregnancy loss, cesarean delivery, ectopic pregnancy, miscarriage, and preterm birth. Multivariate logistic regression, smooth curve fitting, and threshold effect analysis were employed to determine the impact of BMI on LBR.

Results: A nonlinear, inverted U-shaped relationship was identified between female BMI and LBR. The inflection point was 27.18 kg/m²(95% CI: 25.95–28.76). Below this threshold, each 1 kg/m²increment in BMI was associated with a 4% higher probability of live birth (OR 1.04, 95% CI: 1.01–1.08, P=0.005). Above the threshold, each additional BMI unit was associated with a 22% reduction in LBR (OR 0.78, 95% CI: 0.69–0.88, P<0.001). Sensitivity analyses restricted to women with a single ovulated follicle and stratified analyses by endometrial thickness tertiles confirmed the robustness of this nonlinear association. Similar patterns were observed for biochemical and clinical pregnancy rates. Women with BMI ≥ 28 kg/m²exhibited higher rates of biochemical pregnancy loss and cesarean delivery. No significant associations were found between Asian BMI categories and ectopic pregnancy, miscarriage, or preterm birth.

Conclusion: The relationship between female BMI and LBR after the first IUI cycle presents an inverted U-shaped curve, with an optimal BMI around 27.18 kg/m². Both low and high BMI adversely affect live birth outcomes: a modest positive effect is seen in the non-obese range, whereas a pronounced negative effect emerges in the obese range.

Background

Infertility has emerged as a major global public health issue, affecting approximately 186 million people worldwide [1]. In some regions, its prevalence can reach as high as 30% [1]. In the Asia-Pacific region, the prevalence of female infertility has increased more rapidly than that of male infertility [2]. Intrauterine Insemination (IUI) is a cost-effective, non-invasive, first-line treatment option for many infertile couples worldwide, particularly in resource-limited settings [3, 4]. However, its success rate remains relatively low, with reported live birth rates of 8.3% for IUI using homologous semen (174,390 cycles) and 12.2% for IUI with donor semen (41,151 cycles) [5]. As patients often undergo multiple IUI cycles, improving live birth rates is of great clinical importance. Several factors influence IUI outcomes, including female age, sperm quality, timing of insemination, ovarian stimulation protocols, and female body mass index (BMI) [4, 6-8].

Previous studies have demonstrated that both extremely high and low female BMI levels adversely affect pregnancy outcomes in women undergoing in vitro fertilization (IVF) [9, 10]. In contrast, the influence of female BMI on IUI outcomes remains inconsistent across studies, with reports ranging from no significant association [11, 12], to reduced pregnancy rates in women with elevated BMI [13], and even some suggesting a positive effect of overweight on pregnancy rates [14, 15]. These discrepancies may be attributed to variations in BMI cut-off values, differences in inclusion criteria, diverse outcome measures, and/or a failure to account for potential non-linear dose-response relationships between female BMI and IUI outcomes in previous analyses. The ongoing controversy regarding the impact of BMI on live birth rates following IUI poses challenges for clinical decision-making, underscoring the need to identify an optimal BMI threshold for patient guidance.

In this study, we aimed to evaluate the association between female BMI and live birth rates following IUI, with a specific focus on exploring a potential non-linear dose-response relationship and identifying the threshold at which BMI begins to exert a detrimental effect.

Methods

Study Design and Patients

In this retrospective study, we reviewed records of 5651 couples who underwent the first cycle of intrauterine insemination between January 2017 and June 2024 at the Reproductive Medicine Center of Northwest Women’s and Children’s Hospital, China. This study has been approved by the Ethics Committee of Northwest Women’s and Children’s Hospital, with ethical batch number 20250183. Due to the retrospective nature, informed consent was not required and patients' data were used anonymously.

All IUI cycles (n = 15012) performed between January 2017 and June 2024 were considered for inclusion. The indications for IUI were unexplained infertility and infertility caused by cervical factors, ovulation dysfunctions, sexual dysfunctions, endometriosis, mild or moderate male factors. Before beginning therapy, all couples underwent a standard infertility evaluation. All women had at least one patent fallopian tube documented by either hysterosalpingography or laparoscopy. All patients received a comprehensive prepregnancy physical examination to exclude drugs and pregnancy contraindications before IUI cycles. Women were followed for at least 1 year from the IUI treatment

After restricting to artificial insemination by husband (AIH) cycles (n = 10410), we only selected the first AIH cycle for each couple, yielding 5692 cycles for further evaluation.

Exclusion criteria were a) patients with previous IUI cycles in other hospital, b) the canceled IUI cycles only due to poor semen quality or personal factors, c) invalid female BMI value, d) cycles lost to follow-up, e) cycles with induced abortion because of personal or non-medical requests.

Finally, a total of 5651 women who underwent their first cycle of AIH treatment met the criteria for this analysis (Figure 1). The patients' BMIs were calculated as reported weight in kilograms per meter

squared (reported height) at time of IUI start. Patients were categorized into four groups according to Asian BMI classification [16], namely underweight (<18.5 kg/m²), normal weight (≥18.5 to <24 kg/m²), overweight (≥24 to <28 kg/m²), and obese (≥28 kg/m²).

Sperm wash and IUI procedures

The sperm preparation and IUI procedures was performed as previously described [17, 18]. AIH was performed in patients either within 6–12 h after spontaneous LH surge (pre-ovulation) or after ultrasound-confirmed ovulation (post-ovulation). When the leading follicle was >18 mm in diameter without LH surge, 10,000 IU of human chorionic gonadotropin (hCG) was given, and insemination was conducted the next day. Patients who received pre-ovulation AIH continued daily monitoring until ovulation or follicle luteinization. Vaginal micronized progesterone (400 mg/day) was used for 16 days after ovulation as luteal support.

Follow-up: A serum β-hCG test was performed 16 days after luteal support. HCG levels above 7 IU/L indicated biochemical pregnancy. Biochemical pregnancy loss was defined as an initial positive β-hCG test result (β-hCG ≥ 7 IU/L) that subsequently declined. The medication was continued until 10 weeks of pregnancy for patients with persistent pregnancy. Follow up until delivery was continued, and the patient's final pregnancy outcome was recorded. Clinical pregnancy was defined as one or more observed gestational sac or definitive clinical signs of pregnancy under ultrasonography at 7 weeks after IUI (including clinically documented ectopic pregnancy). The spontaneous abortion occurring before 12 weeks of pregnancy is defined as the early miscarriage. Miscarriage was defined as pregnancy loss at <28 weeks. The live birth was defined as the delivery of a living newborn after the 28th gestational week. Multiple pregnancy was defined as a pregnancy with two or more gestational sacs or positive heart beats at 7 weeks of gestation. The preterm birth was defined as birth of a fetus delivered after 28 and before 37 completed weeks of gestational age in participants confirmed ongoing pregnancy.

Outcomes

The primary outcome was live birth rate. Secondary outcomes included biochemical pregnancy rate, biochemical pregnancy losses rate, clinical pregnancy rate, ectopic pregnancy rate, early miscarriage rate, miscarriage rate and perinatal outcomes.

Statistical analysis

Descriptive statistics were used to demonstrate the mean with standard deviation (SD) for continuous variables, and categorical variables were expressed as case numbers and percentages. A univariate analysis was employed to identify potential influencing factors of live birth in IUI cycles. And then a multivariable logistic-regression model was conducted for further analysis including the identified factors. To analyze the effect of female BMI levels on the live birth outcomes of IUI cycles, we performed a smooth curve fit analysis. Then, threshold and saturation effect analysis were employed to explore the cut-off value of BMI levels. with adjustments made for important co-variables and potential confounding

factors (female age, male age, basal FSH, AFC, male factor infertility, anovulatory infertility, unexplained infertility, IUI regimens, number of ovulated follicles). Statistical analysis was performed with R version 4.3.1 (https://www.R-project.org) and EasyR (https://www.easyr. cc Solutions, Inc., Shanghai). Statistical significance was determined by P values < 0.05 in all analyses.

Results

General characteristics of patients and IUI outcomes

General characteristics of patients and IUI outcomes data are presented in Table 1 and Table 2 respectively. Significant differences were observed across BMI categories for most baseline and cycle characteristics. Although statistically significant differences were noted in female and male age across groups (P<0.001), the absolute differences were small. Basal FSH and unexplained infertility decreased with increasing BMI ($p < 0.001$), while AFC and anovulatory infertility increased ($p < 0.001$). In higher BMI categories, ovarian stimulation was employed more frequently ($p < 0.001$), alongside a higher incidence of achieved ovulation ($p = 0.005$).

Reproductive outcomes followed a non-linear pattern, with the overweight group achieving the highest clinical pregnancy (21.61%) and live birth rates (17.88%), while the obese group showed the lowest success rates (14.15% and 11.03%, respectively; p=0.001). Furthermore, biochemical pregnancy loss was significantly elevated in obese women (28.92%, p=0.003), and cesarean delivery rates increased progressively across BMI categories (p<0.001). No significant differences were observed in ectopic pregnancy, early miscarriage, miscarriage, preterm birth, or multiple pregnancy rates across BMI categories.

Univariate analysis

Univariate analysis (Table 3) demonstrated that LBR decreased with advancing female age, male age, and higher basal FSH levels, but increased with higher antral follicle count, the presence of 2 ovulated follicles, and the use of ovulation stimulation protocols. Male factor infertility and anovulatory infertility were associated with increased live birth rates, while unexplained infertility was associated with decreased rates. These variables may act as confounding factors and were adjusted in subsequent analysis. Infertility duration, infertility type, tubal factor, endometriosis, other female factors, postwash TMSC, and IUI timing were not significantly associated with live birth outcomes.

Results of Multiple Regression Models

Multivariable logistic regression analyses were performed to assess the independent association between female BMI and live birth (Table 4). When modeled as a continuous variable, no significant association was observed between per-unit increase in BMI and live birth rate across all models, including the fully adjusted model (Adjust II: OR 1.00, 95% CI 0.97-1.02, P=0.745).

However, when analyzed categorically, a significant non-linear relationship was identified. Compared to the normal weight reference group, obese women (BMI ≥28 kg/m²) demonstrated significantly reduced odds of live birth across all models, with the strongest association observed in the fully adjusted model (Adjust II: OR 0.62, 95% CI 0.44-0.86, P=0.004).

The analyses of non-linear relationship

Given that BMI is a continuous variable, an analysis of its potential non-linear relationship with outcomes was necessary. In the present study, a non-linear association was observed between female BMI and LBR after adjustment for female age, male age, basal FSH, antral follicle count, male factor infertility, anovulatory infertility, unexplained infertility, IUI regimens, and the number of ovulated follicles (Figure 2).

Using a two-piecewise linear regression model adjusted for the aforementioned confounding factors, a significant threshold effect of female BMI on live birth rates was identified (log-likelihood ratio < 0.001). The inflection point was determined to be 27.18 kg/m² (95% CI: 25.95–28.76). Below this threshold, each unit increase in BMI was associated with a 4% higher probability of live birth (OR 1.04, 95% CI: 1.01–1.08, P = 0.005). Conversely, above this threshold, each additional BMI unit was associated with a 22% reduction in the live birth rate (OR 0.78, 95% CI: 0.69–0.88, P < 0.001). The effect difference between the segments before and after the inflection point was 0.74 (OR 0.74, 95% CI: 0.65–0.85, P < 0.001) (Table 5).

Similar nonlinear associations were observed for biochemical and clinical pregnancy rates (Supplementary Figure 1A and Supplementary Figure 1B).

Sensitivity Analysis

A sensitivity analysis was performed in women with a single ovulated follicle (n = 5011) to address potential confounding from multifollicular development (Supplementary Figure 2). The non-linear relationship between BMI and live birth remained significant (log-likelihood ratio test, P<0.001; Supplementary Table 1). The inflection point was 27.43 kg/m², which fell within the 95% confidence interval (25.95–28.76 kg/m²) of the overall population's inflection point (27.18 kg/m²). Below this threshold, each unit increase in BMI was associated with higher live birth rates (OR 1.04, 95% CI: 1.01–1.08, P=0.007). Above this threshold, each additional BMI unit was associated with reduced live birth rates (OR 0.73, 95% CI: 0.63–0.85, P<0.001), representing a potentially stronger effect size compared with the primary analysis (OR 0.73 vs. 0.78).

Stratified analysis based on tertiles of endometrial thickness revealed that the non-linear association between BMI and live birth rate remained evident (Supplementary Figure 3).

Discussion

This retrospective study of 5,651 first IUI cycles clearly demonstrates, for the first time, a significant non-linear threshold relationship between female BMI and LBR, with an inflection point identified at 27.18

kg/m². This pivotal finding offers a novel explanation for reconciling the conflicting conclusions in previous studies regarding BMI and IUI outcomes. Below this threshold, BMI exhibited a modest positive association with the probability of live birth; conversely, above this critical point, it transformed into a strong negative factor, with each additional unit associated with a 22% reduction in the odds of live birth. This complex non-linear dynamic elucidates why the overall effect of BMI was obscured in conventional linear models. Our conclusion remained robust after rigorous adjustment for multivariable confounders. Sensitivity analysis restricted to women with a single ovulated follicle and stratified analysis based on tertiles of endometrial thickness confirmed the robustness of this nonlinear relationship. Additionally, similar nonlinear relationship patterns were observed for biochemical and clinical pregnancy rates. Women with BMI ≥28 kg/m² exhibited higher rates of biochemical pregnancy loss and cesarean delivery. No significant associations were found between different BMI categories and ectopic pregnancy, miscarriage, early miscarriage, or preterm birth rates.

Our findings are partially consistent with those reported by Zheng et al. [14], who demonstrated a significant increase in fertility potential with elevated BMI to a certain extent. However, their exclusion of obese patients (BMI ≥30 kg/m²) and lack of adjustment for critical confounders such as the number of ovulated follicles limit comparability. As multifollicular growth has been reported to be associated with increased pregnancy rates in IUI [19], this represents an important confounding factor. Whynott et al. [20] reported findings largely consistent with ours, indicating that overweight does not negatively affect live birth rates after IUI. However, their exclusion of underweight patients (BMI <18.5 kg/m²) limited the comprehensive assessment of low BMI's impact on IUI outcomes. In contrast, by applying threshold effect analysis, our study identified a precise BMI inflection point (27.18 kg/m²), revealing a previously unreported nonlinear relationship between BMI and IUI success. These findings provide a more refined understanding of this association and contribute valuable insights to the field.

Our findings appear to contradict those reported by Kim et al. [12], who concluded that elevated BMI did not adversely affect IUI success rates. Methodological limitations may explain this observed discrepancy, including the use of dichotomous comparisons (e.g., BMI ≥25 vs. <25 kg/m²), significant heterogeneity among included studies, and the reporting of live birth outcomes in only one study.

Previous recommendations suggested that obese women require higher doses of ovarian stimulation medication; however, BMI itself may not be a determining factor for success rates once medication dosages of ovarian stimulation are appropriately adjusted for weight differences [4]. Our data demonstrated that the utilization of ovarian stimulation protocols increased progressively with higher BMI, accompanied by a decreased proportion of cycles with luteinized unruptured follicle syndrome and an increased rate of multiple follicular development. Our sensitivity analysis in women who achieved a single ovulated follicle revealed a persistent non-linear relationship between BMI and live birth rates, suggesting that medication adjustment alone may not fully explain the complex influence of BMI on IUI outcomes. This finding highlights the need for further investigation into the precise mechanisms through which BMI affects reproductive success.

Souter et al. [21] reported that BMI was positively associated with endometrial thickness, and endometrial thickness was positively associated with pregnancy rates. Our stratified analysis, conducted by dividing endometrial thickness into tertiles, demonstrated that the non-linear relationship between body mass index and live birth rate persisted. This indicates that endometrial thickness is unlikely to be the primary mediator of BMI's impact. This conclusion aligns with evidence from Wattanakumtornkul et al. [22], who demonstrated unimpaired uterine receptivity in women with elevated BMI when hormonal support and embryo quality were standardized, and from Styne-Gross et al. [23], who found no adverse impact of BMI on implantation or reproductive outcomes in oocyte donation recipients—collectively shifting the focus toward oocyte and embryo factors. Since directly assessing oocyte and embryo quality in IUI cycles is challenging, insights from IVF/ICSI data may be informative. Xue et al. [10] demonstrated a significant decline in the number of oocytes retrieved and day-3 embryos with increasing BMI. Furthermore, a review by Robker [24] indicated significant impairments in oocyte maturation, fertilization rate, and embryo quality in obese women. Therefore, the collective evidence suggests that the detrimental effects of obesity on female fertility are likely mediated primarily through compromised oocyte and embryo quality, rather than through impaired endometrial thickness.

Several limitations of this study should be acknowledged. First, despite the large sample size, the retrospective design is inherently susceptible to selection bias. Patients with initial IUI failure often undergo lifestyle modifications before subsequent IUI cycles—such as nutritional support for underweight women weight loss interventions or behavioral adjustments for overweight/obese individuals. These changes may confound the association between BMI and live birth rates. To mitigate this bias, we restricted our analysis to the first IUI cycle. As a result, while our findings offer valuable insights for patients undergoing their initial IUI treatment, they should not be extrapolated to multi-cycle IUI patients. Additionally, unmeasured and unreported confounders may persist. Nevertheless, sensitivity analyses supported the robustness of our primary conclusions.

Conclusion

The relationship between the LBR of IUI and BMI exhibits an inverted U-shaped curve, suggesting that BMI exerts a threshold effect on key IUI success endpoints, with an optimal threshold of approximately 27.18 kg/m². This is the first study to identify a non-linear relationship between BMI and LBR in patients undergoing their first IUI treatment. Both excessively high and low BMI levels may compromise reproductive success, with a modest positive association observed in the non-obese range and a more pronounced negative effect in the obese range, highlighting the importance of considering the optimal BMI range in clinical counseling and treatment planning. These findings provide a new clinical perspective for individualized weight management and assisted reproductive strategies in patients undergoing their first IUI treatment.

Abbreviations

AFC: antral follicle count

AIH: artificial insemination by husband

BMI: body mass index

CI confidence interval

FSH: follicle-stimulating hormone

hCG: human chorionic gonadotropin

IUI: intrauterine insemination

IVF: in vitro fertilization

LBR: live birth rate

LUFS: luteinized unruptured follicle syndrome

NC: natural cycle

OS: ovarian stimulation

OR: odds ratio

ref: reference

TMSC: total motile sperm count

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of Northwest Women's and Children's Hospital (ethical batch number 20250183). The committee waived the requirement for informed consent because the study involved no more than minimal risk to patients (all data were anonymized prior to analysis) and the research could not be practically carried out without the waiver. This decision was made in accordance with the national regulations of China, specifically the "Measures for Ethical Review of Life Sciences and Medical Research Involving Human Subjects" (2023). Therefore, informed consent was not obtained from individual participants.

Consent for publication

Consent.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflicts of interest.

Funding

This work was funded by the Key Research and Development Program of Shaanxi (No.2024SF2-GJHX-20).

Authors' contributions

WW.W. participated in the design of the study and the acquisition of data, performed the statistical analysis, drafted the article, and revised it critically. XF.L. contributed to the conception and design of the study. WH.S. participated in the interpretation of the data and the revision of the article. All authors read and approved the final manuscript.

Acknowledgements

The authors thank all of the medical staff at the Reproductive Medicine Center of Northwest Women's and Children's Hospital for recording all the data in this study over the years.

Author information

Authors and Affiliations

Assisted Reproduction Center, Northwest Women’s and Children’s Hospital, Xi'an, People's Republic of China

Xiaowan Wang, Xiaofang Li & Wenhao Shi

Corresponding authors

Correspondence to Wenhao Shi

References

1. Inhorn MC, Patrizio P: **Infertility around the globe: new thinking on gender, reproductive technologies and global movements in the 21st century.***Hum Reprod Update* 2015, **21:**411-426.
2. Luo Y, Hong C, Fan H, Huang Y, Zhong P, Zhao Y, Zheng X: **Trends and Distribution of Infertility - Asia Pacific Region, 1990-2021.***China CDC Wkly* 2024, **6:**689-694.
3. Ombelet W, Cooke I, Dyer S, Serour G, Devroey P: **Infertility and the provision of infertility medical services in developing countries.***Hum Reprod Update* 2008, **14:**605-621.

4. Cohlen B, Bijkerk A, Van der Poel S, Ombelet W: **IUI: review and systematic assessment of the evidence that supports global recommendations.***Hum Reprod Update* 2018, **24:**300-319.
5. Kupka MS, D'Hooghe T, Ferraretti AP, de Mouzon J, Erb K, Castilla JA, Calhaz-Jorge C, De Geyter C, Goossens V: **Assisted reproductive technology in Europe, 2011: results generated from European registers by ESHRE.***Hum Reprod* 2016, **31:**233-248.
6. Wessel JA, Danhof NA, van Eekelen R, Diamond MP, Legro RS, Peeraer K, D'Hooghe TM, Erdem M, Dankert T, Cohlen BJ, et al: **Ovarian stimulation strategies for intrauterine insemination in couples with unexplained infertility: a systematic review and individual participant data meta-analysis.***Hum Reprod Update* 2022, **28:**733-746.
7. Yavuz A, Demirci O, Sozen H, Uludogan M: **Predictive factors influencing pregnancy rates after intrauterine insemination.***Iran J Reprod Med* 2013, **11:**227-234.
8. Thijssen A, Creemers A, Van der Elst W, Creemers E, Vandormael E, Dhont N, Ombelet W: **Predictive value of different covariates influencing pregnancy rate following intrauterine insemination with homologous semen: a prospective cohort study.***Reprod Biomed Online* 2017, **34:**463-472.
9. Sarais V, Pagliardini L, Rebonato G, Papaleo E, Candiani M, Vigano P: **A Comprehensive Analysis of Body Mass Index Effect on in Vitro Fertilization Outcomes.***Nutrients* 2016, **8:**109.
10. Xue X, Shi W, Zhou H, Tian L, Zhao Z, Zhou D, Shi J: **Cumulative Live Birth Rates According to Maternal Body Mass Index After First Ovarian Stimulation for in vitro Fertilization: A Single Center Analysis of 14,782 Patients.***Front Endocrinol (Lausanne)* 2020, **11:**149.
11. Isa AM, Abu-Rafea B, Alasiri SA, Binsaleh S, Ismail KH, Vilos GA: **Age, body mass index, and number of previous trials: are they prognosticators of intra-uterine-insemination for infertility treatment?** *Int J Fertil Steril* 2014, **8:**255-260.
12. Kim H, Subramanian V, Baird F, Beebeejaun Y, Sarris I, Kamath MS, Sunkara SK: **Effect of female body mass index on intrauterine insemination outcomes: a systematic review and meta-analysis.***Hum Fertil (Camb)* 2023, **26:**1511-1518.
13. Na L, Chen Y, Zhai H, Liao A, Huang D: **Effects of maternal body mass index on pregnancy outcome after 8570 artificial insemination cycles with donor's sperm.***Gynecol Endocrinol* 2018, **34:**1068-1072.
14. Zheng J, Cai J, Liu L, Guo Y, Sun J, Ren J: **Low BMI is associated with poor IUI outcomes: a retrospective study in 13,745 cycles.***J Assist Reprod Genet* 2022, **39:**2819-2825.
15. Wang JX, Warnes GW, Davies MJ, Norman RJ: **Overweight infertile patients have a higher fecundity than normal-weight women undergoing controlled ovarian hyperstimulation with intrauterine insemination.***Fertil Steril* 2004, **81:**1710-1712.
16. **Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies.***Lancet* 2004, **363:**157-163.
17. Zhang D, Cai H, Xie J, Chen L, Zhang Z, Shi J: **Cumulative live birth rates following intrauterine insemination using donor and husband sperm in different age groups: A cohort study of 10 415 insemination cycles.***Int J Gynaecol Obstet* 2024, **167:**142-153.

18. Zhang N, Zhou H: **Optimizing timing for intrauterine insemination (IUI) in donor sperm cycles: pre- versus post-ovulation insemination in natural cycles.***Gynecol Endocrinol* 2024, **40:**2413164.
19. van Rumste MME, Custers IM, van der Veen F, van Wely M, Evers JLH, Mol BWJ: **The influence of the number of follicles on pregnancy rates in intrauterine insemination with ovarian stimulation: a meta-analysis.***Hum Reprod Update* 2008, **14:**563-570.
20. Whynott RM, Summers KM, Van Voorhis BJ, Mejia RB: **Effect of body mass index on intrauterine insemination cycle success.***Fertil Steril* 2021, **115:**221-228.
21. Souter I, Baltagi LM, Kuleta D, Meeker JD, Petrozza JC: **Women, weight, and fertility: the effect of body mass index on the outcome of superovulation/intrauterine insemination cycles.***Fertil Steril* 2011, **95:**1042-1047.
22. Wattanakumtornkul S, Damario MA, Stevens Hall SA, Thornhill AR, Tummon IS: **Body mass index and uterine receptivity in the oocyte donation model.***Fertil Steril* 2003, **80:**336-340.
23. Styne-Gross A, Elkind-Hirsch K, Scott RTJ: **Obesity does not impact implantation rates or pregnancy outcome in women attempting conception through oocyte donation.***Fertil Steril* 2005, **83:**1629-1634.
24. Robker RL: **Evidence that obesity alters the quality of oocytes and embryos.***Pathophysiology* 2008, **15:**115-121.

Tables

Table 1 Baseline and cycle characteristics between different BMI level groups [a].

Female BMI categorical (kg/m²)	Overall (N=5651)	<18.5 (N=503)	≥18.5, <24 (N=3551)	≥24, <28 (N=1180)	≥28 (N=417)	*P*-value
Female BMI (kg/m², mean, SD)	22.47 ± 3.40	17.63 ± 0.77	21.21 ± 1.50	25.55 ± 1.13	30.27 ± 2.05	<0.001
Female age (y, mean, SD)	30.80 ± 3.57	30.18 ± 3.18	30.97 ± 3.49	30.80 ± 3.78	30.06 ± 3.87	<0.001
Male age (y, mean, SD)	32.22 ± 4.12	31.49 ± 3.78	32.41 ± 4.18	32.14 ± 4.11	31.71 ± 3.88	<0.001
Basal FSH (IU/L, mean, SD)	7.15 ± 2.52	8.15 ± 3.89	7.26 ± 2.42	6.69 ± 2.04	6.30 ± 1.83	<0.001
AFC (mean, SD)	13.20 ± 6.10	12.00 ± 5.49	12.85 ± 5.77	14.15 ± 6.68	15.04 ± 7.01	<0.001
Duration of infertility (y, mean, SD)	2.81 ± 1.53	2.59 ± 1.45	2.76 ± 1.50	2.92 ± 1.56	3.18 ± 1.68	<0.001
Infertility type						0.089
Primary Infertility	3790 (67.26%)	362 (72.26%)	2375 (67.00%)	776 (66.21%)	277 (66.43%)	
Secondary Infertility	1845 (32.74%)	139 (27.74%)	1170 (33.00%)	396 (33.79%)	140 (33.57%)	
Infertility factors [b]						
Male factor infertility	3035 (54.08%)	251 (50.20%)	1908 (54.07%)	636 (54.41%)	240 (57.97%)	0.132
Anovulatory infertility	700 (12.42%)	42 (8.38%)	332 (9.37%)	230 (19.62%)	96 (23.02%)	<0.001
Tubal factor	758 (13.45%)	72 (14.37%)	506 (14.27%)	139 (11.86%)	41 (9.83%)	0.022
Endometriosis	226 (4.01%)	25 (4.99%)	156 (4.40%)	39 (3.33%)	6 (1.44%)	0.011
Other female factors [c]	68 (1.21%)	7 (1.40%)	39 (1.10%)	17 (1.45%)	5 (1.20%)	0.783
Unexplained infertility	1816 (32.35%)	184 (36.80%)	1188 (33.65%)	338 (28.91%)	106 (25.60%)	<0.001
Endometrial thickness (mm, mean, SD)	10.85 ± 2.95	10.54 ± 1.84	10.89 ± 3.41	10.78 ± 1.97	11.02 ± 1.97	0.002
Postwash TMSC (10^6)						0.522

<=10	17 (0.31%)	1 (0.20%)	13 (0.37%)	2 (0.17%)	1 (0.24%)	
>10, ≤20	1149 (20.68%)	92 (18.55%)	719 (20.59%)	259 (22.40%)	79 (19.22%)	
>20, ≤30	3065 (55.18%)	293 (59.07%)	1932 (55.33%)	615 (53.20%)	225 (54.74%)	
>30	1324 (23.83%)	110 (22.18%)	828 (23.71%)	280 (24.22%)	106 (25.79%)	
IUI Timing						0.103
Post-ovulation	1653 (29.39%)	142 (28.29%)	1007 (28.47%)	373 (31.91%)	131 (31.49%)	
Pre-ovulation	3971 (70.61%)	360 (71.71%)	2530 (71.53%)	796 (68.09%)	285 (68.51%)	
IUI regimens						<0.001
NC	2838 (50.37%)	301 (59.84%)	1946 (54.96%)	472 (40.20%)	119 (28.61%)	
OS	2796 (49.63%)	202 (40.16%)	1595 (45.04%)	702 (59.80%)	297 (71.39%)	
Cycle cancelation	27 (0.48%)	1 (0.20%)	14 (0.39%)	11 (0.93%)	1 (0.24%)	0.073
Reasons for cycle cancelation						0.703
Multiple follicular development	5 (18.52%)	0 (0.00%)	3 (21.43%)	2 (18.18%)	0 (0.00%)	
Slow follicular growth	6 (22.22%)	0 (0.00%)	3 (21.43%)	2 (18.18%)	1 (100.00%)	
Early ovulation	7 (25.93%)	0 (0.00%)	3 (21.43%)	4 (36.36%)	0 (0.00%)	
LUFS	9 (33.33%)	1 (100.00%)	5 (35.71%)	3 (27.27%)	0 (0.00%)	
Ovulation	5365 (96.23%)	464 (93.36%)	3380 (96.41%)	1123 (96.73%)	398 (96.84%)	0.005
Number of ovulated follicles						0.001
0[d]	210 (3.77%)	33 (6.64%)	126 (3.59%)	38 (3.27%)	13 (3.16%)	
1	5011 (89.88%)	439 (88.33%)	3173 (90.50%)	1042 (89.75%)	357 (86.86%)	

2	345 (6.19%)	25 (5.03%)	201 (5.73%)	78 (6.72%)	41 (9.98%)
3	9 (0.16%)	0 (0.00%)	6 (0.17%)	3 (0.26%)	0 (0.00%)

[a] Data are presented as mean ± SD and n (%).35 missing for basal FSH; 5 missing for AFC; 30 missing for duration of infertility; 16 missing for infertility type, anovulatory infertility, tubal factor, endometriosis and other female factors; 39 missing for male factor infertility; 38 missing for unexplained infertility; 2 missing for endometrial thickness; 95 missing for postwash TMSC; 27 missing for IUI timing; 17 missing for IUI regimens; 49 missing for ovulation and the number of ovulated follicles.

[b] Shown with a maximum of one event per woman.

[c] Shown with cervical factor/female infrequent intercourse/dyspareunia

[d] Shown with LUFS.

Abbreviations: AFC, antral follicle count; FSH, follicle-stimulating hormone; BMI, body mass index; IUI, intrauterine insemination; LUFS, luteinized unruptured follicle syndrome; NC, natural cycle; OS, ovarian stimulation; TMSC, total motile sperm count.

Table 2 Reproductive outcomes of IUI between different BMI level groups

Female BMI categorical (kg/m²)	Overall (N=5651)	<18.5 (N=503)	≥18.5, <24 (N=3551)	≥24, <28 (N=1180)	≥28 (N=417)	*P*-value
Biochemical pregnancy	1209 (21.39%)	91 (18.09%)	732 (20.61%)	303 (25.68%)	83 (19.90%)	<0.001
Clinical pregnancy	1026 (18.16%)	80 (15.90%)	632 (17.80%)	255 (21.61%)	59 (14.15%)	0.001
Live birth	838 (14.83%)	62 (12.33%)	519 (14.62%)	211 (17.88%)	46 (11.03%)	0.001
Biochemical pregnancy loss	183 (15.14%)	11 (12.09%)	100 (13.66%)	48 (15.84%)	24 (28.92%)	0.003
Ectopic pregnancy	21 (2.05%)	4 (5.00%)	12 (1.90%)	3 (1.18%)	2 (3.39%)	0.169
Early Miscarriage	146 (14.53%)	14 (18.42%)	90 (14.52%)	33 (13.10%)	9 (15.79%)	0.701
Miscarriage	164 (16.32%)	14 (18.42%)	100 (16.13%)	39 (15.48%)	11 (19.30%)	0.858
Preterm birth	68 (8.13%)	7 (11.29%)	34 (6.58%)	23 (10.90%)	4 (8.70%)	0.196
Multiple pregnancy	20 (2.39%)	1 (1.61%)	16 (3.08%)	1 (0.47%)	2 (4.35%)	0.150
Mode of delivery						<0.001
Vaginal delivery	336 (40.14%)	33 (53.23%)	226 (43.55%)	65 (30.95%)	12 (26.09%)	
Cesarean section	501 (59.86%)	29 (46.77%)	293 (56.45%)	145 (69.05%)	34 (73.91%)	

Data are presented as mean ± SD and n (%).12 missing for preterm birth; 1 missing for mode of delivery.

Table 3 The results of univariate analysis [a]

Statistics	Effect size	*P* value	
Female BMI (kg/m²)			
Normal weight (18.5-24 kg/m²)	3551(62.84%)	ref	
Underweight (<18.5 kg/m²)	503(8.90%)	0.82(0.62,1.09)	0.1708
Overweight (24-28 kg/m²)	1180(20.88%)	1.27(1.07,1.52)	0.0072
Obese (≥28 kg/m²)	417(7.38%)	0.72(0.53,1.00)	0.0484
Female age (y, mean, SD)	30.80 ± 3.57	0.96 (0.94, 0.98)	0.0002
Male age (y, mean, SD)	32.22 ± 4.12	0.98 (0.96, 0.99)	0.0082
Basal FSH (IU/L, mean, SD)	7.15 ± 2.52	0.96 (0.93, 0.99)	0.0124
AFC (mean, SD)	13.20 ± 6.10	1.03 (1.02, 1.04)	<0.0001
Endometrial thickness(mm)	10.85 ± 2.95	1.00 (0.98, 1.03)	0.7077
Infertility type			
Primary Infertility	3790 (67.26%)	ref	
Secondary Infertility	1845 (32.74%)	1.02 (0.87, 1.19)	0.8138
Duration of infertility (y, mean, SD)	2.81 ± 1.53	0.96 (0.91, 1.00)	0.0764
Postwash TMSC (10^6)			
<=10	17 (0.31%)	ref	
>10, ≤20	1149 (20.68%)	2.68 (0.35, 20.37)	0.3399
>20, ≤30	3065 (55.18%)	2.82 (0.37, 21.30)	0.3154
>30	1324 (23.83%)	2.91 (0.38, 22.10)	0.3007
Male factor infertility			
NO	2577 (45.92%)	ref	
YES	3035 (54.08%)	1.21 (1.04, 1.40)	0.0141
Anovulatory infertility			
NO	4935 (87.58%)	ref	
YES	700 (12.42%)	1.41 (1.15, 1.73)	0.0010
Tubal factor			
NO	4877 (86.55%)	ref	
YES	758 (13.45%)	0.98 (0.79, 1.22)	0.8614

Endometriosis			
NO	5409 (95.99%)	ref	
YES	226 (4.01%)	0.67 (0.44, 1.03)	0.0695
Other female factors [b]			
NO	5567 (98.79%)	ref	
YES	68 (1.21%)	1.49 (0.83, 2.70)	0.1838
Unexplained Infertility			
NO	3797 (67.65%)	ref	
YES	1816 (32.35%)	0.82 (0.70, 0.97)	0.0193
IUI regimens			
NC	2838 (50.37%)	ref	
OS	2796 (49.63%)	1.27 (1.09, 1.47)	0.0016
IUI Timing			
Post-ovulation	1653 (29.39%)	ref	
Pre-ovulation	3971 (70.61%)	1.11 (0.94, 1.31)	0.2085
Number of ovulated follicles			
1	5011 (93.40%)	ref	
2	345 (6.43%)	2.08 (1.62, 2.68)	<0.0001
3	9 (0.17%)	1.66 (0.34, 8.02)	0.5267

[a] Chi-squared test or Fisher's exact test. Data are presented as mean ± SD/ n (%), β (95%CI) / OR (95%CI)

[b] Shown with cervical factor/female infrequent intercourse/dyspareunia

Abbreviations: AFC, antral follicle count; FSH, follicle-stimulating hormone; BMI, body mass index; IUI, intrauterine insemination; NC, natural cycle; OS, ovarian stimulation; ref, reference; TMSC, total motile sperm count.

Table 4 Association between female BMI and live birth outcome

Exposure	Non-adjusted Model OR (95% CI)	*P*-value	Adjust I Model OR (95% CI)	*P*-value	Adjust II Model OR (95% CI)	*P*-value
Female BMI (kg/m²)	1.01 (0.99, 1.03)	0.3393	1.01 (0.99, 1.03)	0.3972	1.00 (0.97, 1.02)	0.7450
Female BMI (kg/m²) categorical						
Normal weight (18.5-24 kg/m²)	ref		ref		ref	
Underweight (<18.5 kg/m²)	0.82 (0.62, 1.09)	0.1708	0.79 (0.60, 1.05)	0.1108	0.83 (0.62, 1.11)	0.2044
Overweight (24-28 kg/m²)	1.27 (1.07, 1.52)	0.0072	1.26 (1.06, 1.50)	0.0095	1.19 (0.99, 1.43)	0.0668
Obese (≥28 kg/m²)	0.72 (0.53, 1.00)	0.0484	0.69 (0.50, 0.96)	0.0263	0.62 (0.44, 0.86)	0.0044

Non-adjusted model: Adjusted for none.
Adjust I model: Adjusted for female age.
Adjust II model: Adjusted for female age, male age, basal FSH, AFC, male factor infertility, anovulatory infertility, unexplained infertility, IUI regimens, number of ovulated follicles
Abbreviations: OR, odds ratio; CI, confidence interval; ref, reference

Table 5 The results of two-piecewise linear regression model

Outcome	Infertility (OR, 95% CI)	*P* value
Inflection point (K, 95%CI)	27.18 (25.71, 28.72)	
<27.18 kg/m²	1.04 (1.01, 1.08)	0.0054
>27.18 kg/m²	0.78 (0.69, 0.88)	<0.0001
effect difference	0.74 (0.65, 0.85)	<0.0001
Log-likelihood ratio	<0.001	

Effect: Live birth

Cause: female BMI (kg/m^2)

Adjusted: female age, male age, basal FSH, AFC, male factor infertility, anovulatory infertility, unexplained infertility, IUI regimens, number of ovulated follicles

Abbreviation: CI, confidence interval; OR, odds ratio.

Figures

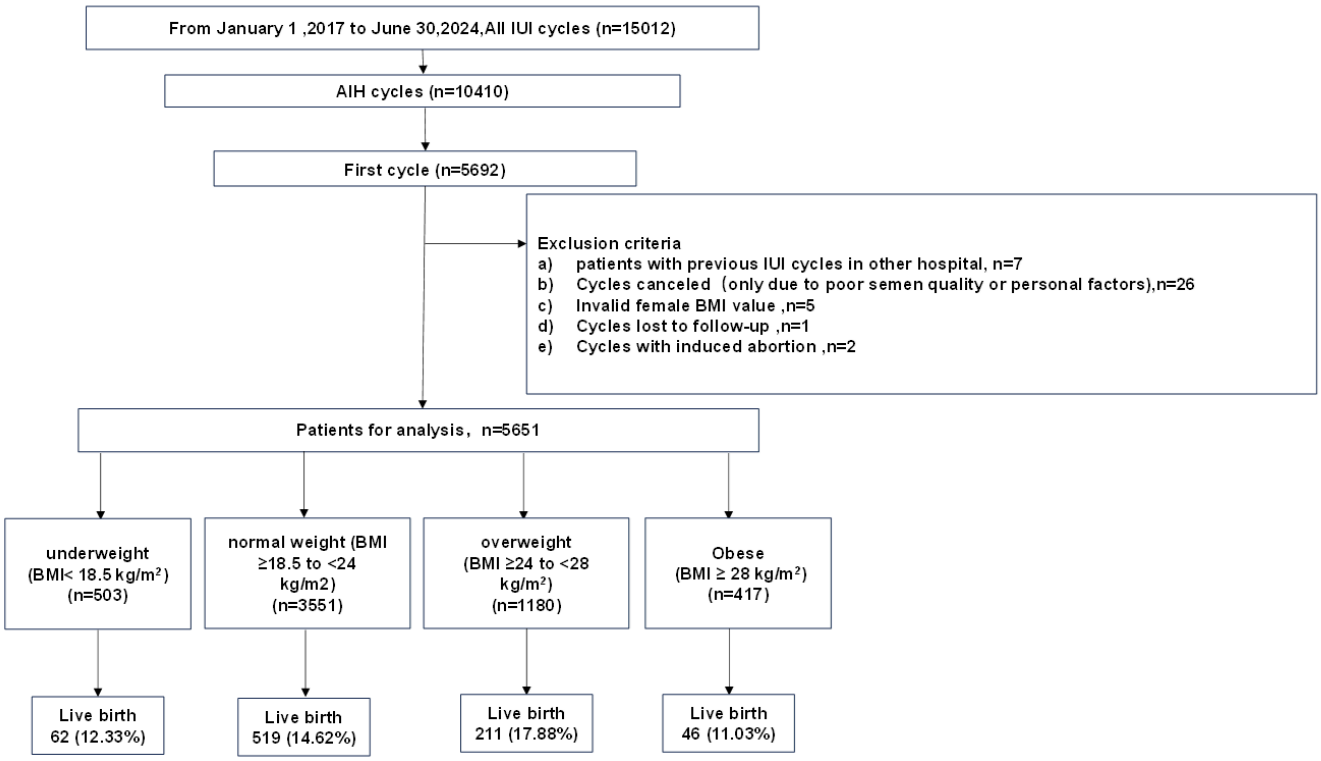


Figure 1

Flow chart of the study cohort

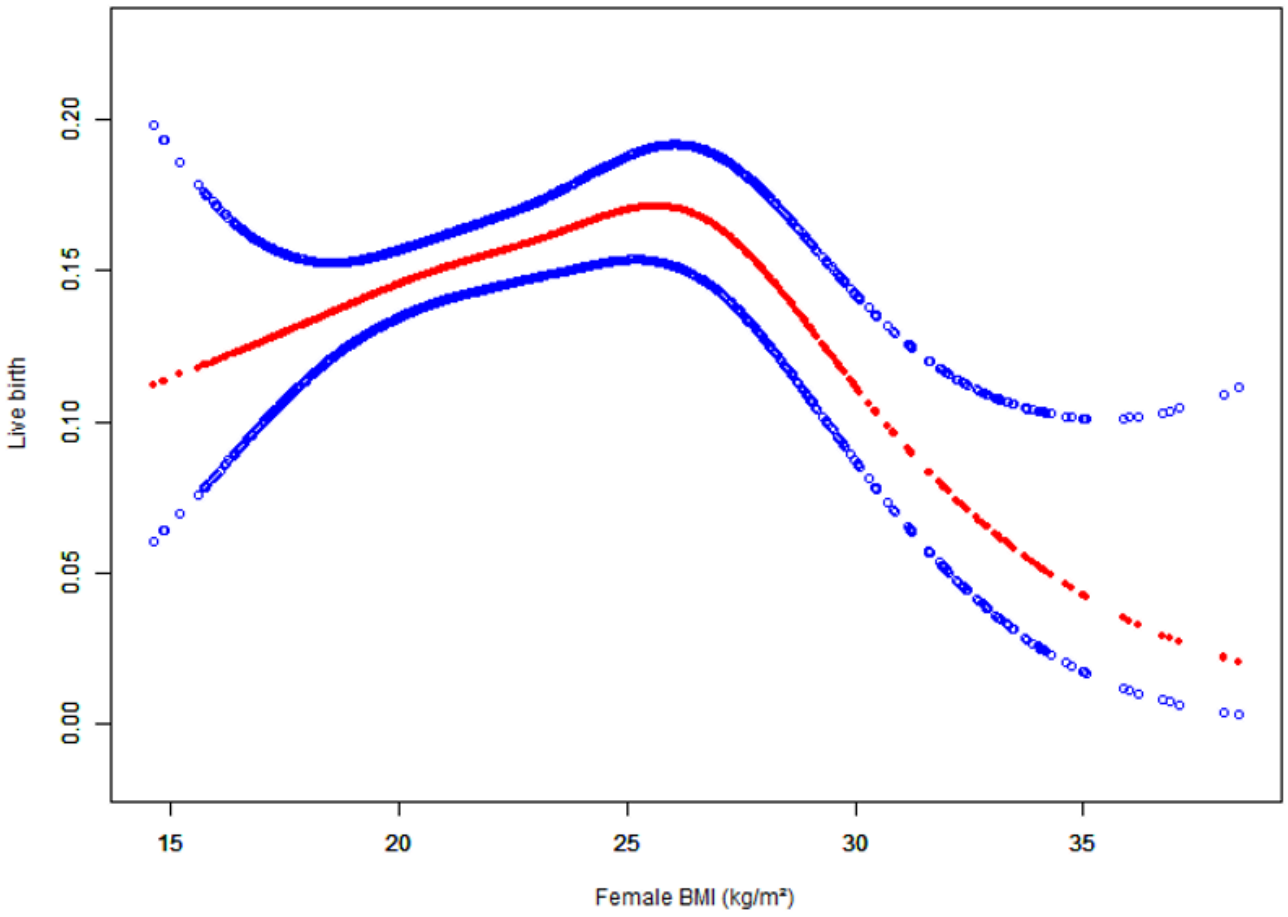


Figure 2

The relationship between BMI and live birth. A nonlinear relationship between them was detected after adjusting for female age, male age, basal FSH, AFC, male factor infertility, anovulatory infertility, unexplained infertility, IUI regimens, number of ovulated follicles

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFigures.docx
- SupplementaryTable1.docx