



Association of Metabolic Syndrome Components With In Vitro Fertilization Outcomes in Women: A Cross-Sectional Study

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Abstract

Introduction: Metabolic syndrome is defined by conditions such as insulin resistance, central obesity, dyslipidemia, and hypertension. These factors can negatively impact female reproductive function.

Objectives: This study aimed to compare the components of metabolic syndrome in women with successful and unsuccessful IVF outcomes.

Methods: This cross-sectional study was conducted in 2024 at a private infertility clinic in Mashhad, Iran, among women undergoing in vitro fertilization (IVF). Participants were divided into two groups: those who experienced successful IVF outcomes and those who did not. Metabolic syndrome was defined according to the criteria established by the National Cholesterol Education Program Adult Treatment Panel III. The study collected data on demographic characteristics, FBS, TG, HDL-C, waist circumference, blood pressure, and duration of infertility. Data analysis was performed using SPSS version 20.

Results: A total of 24 women participated in this study, comprising 12 individuals with successful IVF outcomes and 12 individuals with unsuccessful outcomes. Statistical analysis revealed no significant differences between the two groups in age, body mass index, blood pressure, lipid profile, waist circumference, or medical history ($P > 0.05$). However, median FBS levels were significantly higher in the unsuccessful IVF group than in the successful group ($P = 0.03$). Additionally, the duration of infertility was significantly longer in the unsuccessful group ($P = 0.02$).

Conclusion: Elevated fasting blood glucose levels and extended durations of infertility were found to be associated with unsuccessful outcomes in IVF procedures. These results suggest that even minor disturbances in glucose metabolism can adversely affect IVF success rates.

Keywords: Metabolic syndrome; Fasting blood glucose; In vitro fertilization; Infertility; Body mass index

1. Introduction

Metabolic syndrome (MS) is a complex metabolic disorder defined by a combination of factors, including central obesity, impaired glucose metabolism, dyslipidemia, and hypertension. MS has emerged as a significant public health concern globally due to its strong links to cardiovascular disease, type 2 diabetes mellitus, and an increased risk of overall mortality (1,2).

The incidence of MS has increased dramatically over recent decades, particularly among women of reproductive age. This rise can be attributed primarily to sedentary lifestyles, poor dietary choices, and rising obesity rates (3). MS, which is well-known for its effects on cardiometabolic health, is increasingly associated with reproductive dysfunction in women. Key components of MS, including insulin resistance, hyperglycemia, and excess body fat, can disrupt the hypothalamic-pituitary-ovarian axis. This disruption negatively affects follicle development, alters sex hormone metabolism, and adversely affects ovulation (4,5,6). These metabolic disturbances can compromise endometrial receptivity and embryo implantation, thereby decreasing the chances of a successful pregnancy (7).

Infertility is a common reproductive health issue that affects about 10 to 15% of couples around the world. IVF is one of the most effective assisted reproductive technologies for managing infertility. However, despite significant advancements in laboratory techniques and ovarian stimulation protocols, the success rates of IVF remain relatively limited. Identifying modifiable metabolic and clinical factors that affect IVF outcomes is of significant clinical importance (8). Growing evidence indicates that metabolic issues can negatively impact IVF results. Obesity and insulin resistance are linked to decreased oocyte quality, changes in embryo development, lower implantation rates, and increased miscarriage rates (9–11). Women with metabolic syndrome, especially those with impaired glucose metabolism, may experience poorer reproductive outcomes, even without overt diabetes mellitus (12). However, previous studies have reported inconsistent findings regarding the role of individual components of metabolic syndrome—such as fasting blood glucose, lipid profile, and waist circumference—in IVF outcomes. Additionally, data from Middle Eastern populations remains limited (15). Additionally, the duration of infertility has been identified as a significant prognostic factor in assisted reproductive treatments. Extended infertility may indicate accumulated endocrine, metabolic, and ovarian changes that adversely affect treatment outcomes (16). The impact of metabolic syndrome components and infertility duration on IVF success has not been thoroughly investigated (17).

2. Objectives

With the increasing prevalence of MS and its possible effects on reproductive health, this study aimed to compare the components of MS and the duration of infertility among women with successful and unsuccessful outcomes from IVF. Understanding these connections may help identify high-risk patients and emphasize the importance of metabolic evaluation and optimization before starting IVF.

3. Materials and Methods

3.1. Study Design

This cross-sectional study was conducted in 2024 at a private infertility clinic in Mashhad, Iran. Women aged 18 to 50 undergoing IVF were enrolled. The study was approved by the Research Ethics Committee of Islamic Azad University, Mashhad Branch (IR.IAU.MSHD.REC.1402.180). Written informed consent was obtained from all participants.

3.2. Participants

Women aged 18 to 50 undergoing IVF were included in the research, and no specific exclusion criteria were set. Participants were divided into two groups based on the outcome of their IVF:

those with a successful outcome and those with an unsuccessful outcome.

3.3. Data gathering

We recorded demographic information, including age, height, weight, body mass index (BMI), and duration of infertility. Blood pressure was measured using a standard sphygmomanometer after the participants rested for 10 minutes. Blood samples were collected following an overnight fasting period to assess fasting blood glucose (FBS), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) within a single laboratory setting. Additionally, waist circumference was measured at the level of the umbilicus using a standardized tape measure. Metabolic syndrome was defined according to the NCEP/ATP III criteria as the presence of three or more of the following components: Waist circumference ≥ 88 cm, Fasting blood glucose ≥ 100 mg/dL or treatment for hyperglycemia, Triglycerides ≥ 150 mg/dL or treatment for high triglycerides, HDL-C < 50 mg/dL or treatment to increase HDL, Blood pressure $\geq 130/85$ mmHg or treatment for hypertension (1).

3.4. Statistical analysis

Data were analyzed using IBM SPSS Statistics version 20. Normality was assessed using the Kolmogorov–Smirnov test. Independent t-tests or Mann–Whitney U tests were applied as appropriate. Categorical variables were analyzed using chi-square or Fisher's exact tests. A P-value < 0.05 was considered statistically significant.

4. Results

A total of 24 women undergoing IVF were included in the final analysis and were classified into successful and unsuccessful IVF outcome groups. The baseline characteristics of the study population are summarized in Table 1. The mean age of participants was 33.16 ± 6.45 years, and the mean body mass index (BMI) was 26.48 ± 4.13 kg/m². Overall, 33% of the participants reported a history of underlying medical conditions, while the majority (95%) were normotensive at the time of assessment. The baseline demographic and anthropometric characteristics were similar between the two groups. As shown in Table 2, there were no statistically significant differences in age, height, weight, or BMI between women with successful and unsuccessful IVF outcomes (all $P > 0.05$). This suggests that the study population was homogeneous with respect to these demographic factors.

The comparison of MS parameters between the two groups is presented in Table 3. A statistically significant difference in FBS levels was noted between the groups. Women with unsuccessful IVF outcomes had notably higher median FBS levels compared to those who achieved successful IVF outcomes (99 mg/dL vs. 90 mg/dL; $P = 0.03$). Furthermore, the median duration of infertility was significantly longer in the unsuccessful IVF group than in the successful group (3.85 years vs. 3 years; $P = 0.02$). In contrast, no significant differences were detected between the two groups regarding serum triglyceride levels, HDL-C, systolic or diastolic blood pressure, waist circumference, or the number of MS components (all $P > 0.05$), as detailed in Table 3.

The frequency of MS was low in both groups. As shown in Table 4, there was no statistically significant difference in the prevalence of metabolic syndrome between women with successful and unsuccessful IVF outcomes ($P > 0.05$). Additionally, an analysis of underlying medical conditions revealed no significant differences between the two groups (Table 5). The overall frequency and distribution of comorbid conditions were similar among women

with both successful and unsuccessful IVF outcomes ($P > 0.05$).

Table 1. The mean values of the variables in patients.

Variable	Lowest	Highest	Mean±SD
Body Mass Index	17.37	33.73	26.48±4.13
Systolic Blood Pressure	80	120	100.20±12.02
Diastolic Blood Pressure	60	80	65.00±7.80
HDL	35	120	56.29±24.46
FBS	78	140	95.41±14.43
TG	47	211	97.54±40.77
Waist Circumference	52	154	87.95±21.93
Duration of Infertility (Year)	2.5	5	3.48±0.63
Number of Metabolic Syndrome Criteria	0	3	1.16±0.63

Table 2. The comparison of participants' demographic variables across study groups.

Variable	Successful IVF Mean ± SD	Unsuccessful IVF Mean ± SD	P-value
Age	32.25±6.42	34.08±6.62	0.49
Height	161.50±5.50	165.16±3.25	0.15
Weight	68.16±13.68	77.00±7.89	0.16
Body Mass Index	26.17±5.08	26.80±3.10	0.71

Table 3. The comparison of metabolic syndrome variables across study groups

Variable	Successful IVF	Unsuccessful IVF	P-value
TG	95.00±48.85	100.08±32.79	0.76
Systolic blood pressure	98.75±11.70	101.66±12.67	0.56
Diastolic blood pressure	63.33±6.51	66.66±8.87	0.30
HDL	49(42.75, 50)	47.5(41.75, 91.25)	0.97
FBS	90(83.5, 95)	99(91.75, 110.25)	0.03
Waist circumference	81.5(79, 87.5)	85(79.75, 87.5)	0.74
Number of metabolic syndrome criteria	1(1, 1.25)	1(1, 1)	0.71
Duration of infertility (Year)	3(3, 3.5)	3.85(3.375, 4.125)	0.02

Table 4. The prevalence of metabolic syndrome across study groups

Variable	Successful IVF (n%)	Unsuccessful IVF (n%)	P-value
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Metabolic syndrome	Present	0 (0)	1 (8.13)	0.30
	Absent	12 (100)	11 (91.7)	

Table 5. The comparison of the frequency of underlying diseases among participants in each study group

Underlying disease	Successful IVF (n%)	Unsuccessful IVF (n%)	P-value
Hypothyroidism	2 (16.7)	4 (33.4)	0.56
Diabetes mellitus	1 (8.3)	1 (8.3)	
Depression	0 (0.0)	1 (8.3)	
IBD	1 (8.3)	0 (0.0)	
None	8 (66.7)	6 (50.0)	

5. Discussion

The current study examined the relationship between MS components and IVF outcomes. The results show that higher fasting blood glucose levels and a longer duration of infertility were significantly linked to unsuccessful IVF outcomes. In contrast, other components of MS, such as lipid profile parameters and waist circumference, did not differ significantly between the successful and unsuccessful IVF groups.

One of the key findings of this study was that women with unsuccessful IVF outcomes exhibited significantly higher FBS levels. This difference was observed even within a near-normal range of glucose levels, indicating that mild disturbances in glucose metabolism may negatively impact reproductive outcomes. Previous research has shown that hyperglycemia and insulin resistance can disrupt ovarian steroidogenesis, impair oocyte maturation, and compromise endometrial receptivity. These factors are critical for successful implantation and pregnancy. These metabolic alterations may lead to suboptimal follicular development and impaired embryo–endometrium interaction, thereby reducing the likelihood of IVF success even in the absence of overt diabetes or clinically diagnosed metabolic syndrome (11–13).

The current study's findings align with those of He et al.(8), who showed that MS and its related metabolic disturbances negatively impact ovarian response and IVF outcomes in women with polycystic ovary syndrome (PCOS). Although the current study included a broader infertility population rather than exclusively women with PCOS, the observed association between elevated FBS and IVF failure suggests that impaired glucose metabolism represents a shared pathogenic pathway influencing reproductive outcomes across different infertility etiologies.

In addition to glycemic status, the duration of infertility has been identified as a significant predictor of IVF outcomes. Women who experienced unsuccessful IVF attempts had a notably longer history of infertility compared to those who achieved success. This finding is consistent with previous research, which has identified a prolonged duration of infertility as a negative prognostic factor for the success of assisted reproductive technologies (14). A longer

duration of infertility may indicate a progressive decline in ovarian reserve, cumulative hormonal and metabolic imbalances, or a delay in starting effective fertility interventions. These factors may collectively contribute to reduced responsiveness to ovarian stimulation and lower implantation potential (18).

Numerous studies conducted within populations diagnosed with PCOS have identified associations between obesity, dyslipidemia, and adverse outcomes in IVF (8–10). The present study did not reveal significant differences in BMI, serum triglyceride levels, HDL-C levels, or waist circumference among the groups. This discrepancy may be attributed to variations within the study populations, as participants included women with diverse etiologies of infertility rather than exclusively those diagnosed with PCOS. Furthermore, the relatively small sample size may have limited the statistical power to detect subtle differences in lipid and anthropometric parameters. Other studies have reported similar findings, suggesting that individual metabolic abnormalities may have a greater impact on IVF outcomes than the overall MS classification (9,10).

The absence of a significant difference in the overall prevalence of MS between successful and unsuccessful IVF groups suggests that individual metabolic components—especially fasting blood glucose—might be more sensitive predictors of IVF outcomes than the broader criteria for MS. This finding underscores the potential clinical value of conducting targeted metabolic assessments rather than relying solely on established MS definitions. Therefore, optimizing specific metabolic parameters, particularly glycemic control, before initiating IVF may be an effective strategy to improve reproductive success.

This study had several limitations, including a small sample size, a cross-sectional design, and the absence of assessment of insulin resistance indices, such as HOMA-IR. Additionally, pregnancy outcomes beyond IVF success, such as live birth rates, were not evaluated.

6. Conclusion

This study finds that higher fasting blood glucose levels and a longer duration of infertility are linked to unsuccessful IVF outcomes. Even minor increases in fasting blood glucose, still

within the normal range, can negatively impact reproductive success. The results highlight the association between metabolic health and IVF outcomes, showing that mild metabolic disturbances, often missed in routine evaluations, can significantly affect success rates. Thus, incorporating metabolic screening and personalized optimization into pre-IVF assessments may enhance reproductive success.

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Ethical Approval

The present study has a code of ethics with an ID number (IR.IAU.MSHD.REC.1402.180).

Consent to participate

Written informed consent was obtained from the parents of all participants included in the study. **Conflict of Interest** None.

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None.

Author Contribution

Conceptualization: BS - Methodology and Formal analysis: RK- Investigation, Data curation: BS and RK - Writing- Original draft: RK - Writing - review & editing: BS and RK and AN.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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