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Research Article

The Association of BMI and TSH Levels with IVF/ICSI Outcomes

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Abstract

Objective: This study aimed to investigate the relationship between thyroid-stimulating hormone (TSH) levels, body mass index (BMI), and the success or failure of in vitro fertilization (IVF), as well as pregnancy outcomes in women undergoing IVF/ICSI treatment.

Methods: In this case-control study, data were collected from 278 infertile couples referred to infertility centers affiliated with Shiraz University of Medical Sciences between 2016 and 2023. Demographic variables, hormone levels, TSH, BMI, and additional factors such as infertility duration and varicocele status were analyzed. Statistical analysis was conducted using SPSS software.

Results: Of the participants, 137 achieved successful IVF outcomes. BMI, TSH levels, and hypothyroidism were not significantly correlated with IVF/ICSI success or live birth rates. Secondary infertility cases demonstrated higher success rates, and men with untreated varicocele were linked to better IVF outcomes.

Conclusion: BMI and TSH levels showed no significant association with IVF success or live birth outcomes. However, secondary infertility and untreated male varicocele were associated with improved pregnancy results. Further research with larger samples and detailed sub-categorization of infertility causes is recommended.

Keywords: pregnancy, body mass index, thyroid-stimulating hormone, in vitro fertilization

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1. Introduction

Infertility is recognized as one of the most significant health challenges worldwide, affecting one in every six individuals. According to the World Health Organization (WHO), infertility is defined as the inability to conceive after one year of regular, unprotected intercourse without using contraceptive methods. WHO categorizes infertility into two types: primary infertility, which is the inability to conceive for the first time, and secondary infertility, which refers to the inability to conceive after a previous successful pregnancy [1].

Fertility is influenced by a combination of factors, including genetic, hormonal, anatomical, environmental, and psychological elements. Female-specific factors, such as ovulation disorders, polycystic ovary syndrome (PCOS), and endometriosis, as well as male-specific factors, such as varicocele and reduced sperm count or quality, are among the primary contributors to infertility [2-4]. Additionally, lifestyle and environmental factors, such as stress, depression, alcohol consumption, smoking, dietary habits, exposure to pollution, and harmful chemicals, significantly impact fertility [5-7].

Weight gain and obesity, which have become increasingly prevalent in the general population and among women of reproductive age, are strongly associated with reduced fertility rates, lower live birth rates (LBR), and higher incidences of menstrual disorders, PCOS, and pregnancy complications, including diabetes, preeclampsia, miscarriage, stillbirth, and preterm birth [8-14]. This correlation is attributed to the increased conversion of androgens to estrogens and the decreased production of sex hormone-binding globulin (SHBG) in the liver. These changes result in excessive secretion of luteinizing hormone (LH), an elevated androgen-to-estrogen ratio, and disruptions in folliculogenesis [15].

Furthermore, scientific evidence suggests that obesity and being overweight are linked to heightened insulin resistance, triggering an inflammatory response and the release of cytokines. This process elevates C-reactive protein (CRP) levels, which negatively affect endothelial cell activity, fertility, placental health, and pregnancy outcomes [16,17].

However, there is conflicting evidence regarding the impact of increased body mass index (BMI) on in vitro fertilization (IVF) outcomes. While some studies indicate that overweight and obesity adversely affect IVF success [18,19], others do not report significant findings [19]. On the other hand, the quality of female eggs (genetically normal ova) plays a crucial role in IVF success [20]. Given the significance of thyroid hormones in oocyte physiology and egg quality [21,22], and their potential influence on IVF outcomes, the present study aims to explore the effects of increased BMI and thyroid-stimulating hormone (TSH) levels on IVF results.

2. Materials and Methodology

2.1. Sample Collection

This retrospective case-control study was conducted on the records of 278 infertile couples who sought IVF/ICSI treatment at the Hazrat-e Zainab and Mother and Child Hospitals, both affiliated with Shiraz

University of Medical Sciences (SUMS), between 2016 and 2023. Data were extracted from the infertility registry system and patient hospital charts, including demographic, anthropometric, and laboratory information. Additionally, treatment details, such as the type of treatment, treatment plans (e.g., surgical methods, drug therapy, and hormone therapy), and post-treatment follow-ups, were collected.

2.2. Inclusion Criteria and Study Variables

Study variables included demographic factors (e.g., age and the duration of primary or secondary infertility), anthropometric factors (e.g., body mass index (BMI), calculated as weight (kg) divided by height squared (m^2)), and clinical factors (e.g., TSH levels, women's underlying conditions such as hypothyroidism, and men's conditions such as varicocele or a history of varicocelectomy). According to WHO guidelines, individuals were classified based on their BMI as underweight (BMI $<$ 18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25–29.9), and obese (BMI $\geq$ 30) [23]. Successful IVF was defined as a positive beta-hCG test. The study group was further divided into two subgroups based on pregnancy outcomes: live births and adverse outcomes, including miscarriage and stillbirth.

2.3. Data Analysis

Following data collection and coding, the information was analyzed using SPSS version 18 software. Mean and standard deviation were used to describe quantitative variables, while numbers and percentages were applied for qualitative variables. Relationships between variables and IVF success or pregnancy outcomes were examined using chi-square tests, Mann-Whitney U tests, and t-tests. Statistical significance was set at a p-value $<$ 0.05.

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3. Results

3.1. Demographic Data and Medical History

This study evaluated 278 women, divided into two groups: successful IVF (137 women) and unsuccessful IVF (141 women). The successful IVF group was further categorized based on pregnancy outcomes into live births (90 women) and adverse pregnancy outcomes (47 women). In this study, adverse pregnancy outcomes were defined as miscarriage (abortion) and stillbirth.

According to Table **1**, the average age of women in the successful and unsuccessful IVF groups was 34.36 $\pm$ 6.11 and 34.55 $\pm$ 5.71, respectively. Additionally, the average BMI in both groups was within the overweight range. The mean duration of primary infertility was 5.1 $\pm$ 3.5 years in the successful IVF group

and 5.7 ± 3.7 years in the unsuccessful IVF group, while the mean duration of secondary infertility was 4.43 ± 2.1 years and 4.20 ± 2.28 years, respectively. Statistical analysis showed no significant differences between the groups for age, BMI, and duration of primary and secondary infertility ($p > 0.05$) (Table **1**).

Table 1: The mean and standard deviation of demographic and anthropometric characteristics, as well as the years of infertility, were analyzed for women in the successful IVF group and the unsuccessful IVF group.

Variable	IVF		p-value	test
	Success (137 women)	Failure (141 women)		
	Standard deviation ± mean	Standard deviation ± mean		
Age (years)	34.36 ± 6.11	34.55 ± 5.71	0.254	t-test
Body Mass Index	25.58 ± 3.57	25.76 ± 4.19	0.697	t-test
Thyroid Stimulating Hormone	2.39 ± 1.08	2.31 ± 1.36	0.615	t-test
Years of primary infertility	5.1 ± 3.5	5.7 ± 3.7	0.153	t-test
Years of secondary infertility	4.43 ± 2.1	4.20 ± 2.28	0.830	t-test

The average TSH levels were 2.39 ± 1.08 in the successful IVF group and 2.31 ± 1.36 in the unsuccessful IVF group, with no statistically significant difference between the two groups ($p > 0.05$).

Regarding underlying conditions, 23.4% of women in the successful IVF group and 21.3% in the unsuccessful IVF group had hypothyroidism, a difference that was not statistically significant. However, analysis of spouses' underlying conditions revealed that 17.5% of the spouses of women in the successful IVF group had varicocele, with 10.9% of those having undergone varicocelectomy. In contrast, only 3.5% of the spouses in the unsuccessful IVF group had varicocele, but 11.9% had undergone varicocelectomy. This difference was statistically significant.

Furthermore, 76.6% of women in the successful IVF group had primary infertility, compared to 98.6% in the unsuccessful IVF group. Conversely, 23.4% of women in the successful IVF group had secondary infertility, compared to only 1.4% in the unsuccessful IVF group. These differences were statistically significant ($p < 0.05$) (Table **2**).

Table 2: Comparison of hypothyroidism, primary and secondary infertility, varicocele, and varicocelectomy in couples with successful and unsuccessful IVF outcomes.

Variable	IVF		p-value	test
	Success (137 couples)	Failure (141 couples)		
Hypothyroidism (women)	23.4%	21.3	0.677	Chi-square
Primary infertility (women)	76.6%	98.6%	0.000	Chi-square
Secondary infertility(women)	15.3%	5.3%	0.001	Chi-square
Varicocele (men)	17.5%	3.5%	0.001	Chi-square
Varicocelectomy (men)	10.9%	11.9%	0.001	Chi-square

3.2. Pregnancy Outcome

According to Table **3**, the average age of women with adverse pregnancy outcomes and those with live birth outcomes was 34.37 ± 6.5 and 34.31 ± 5.9 years, respectively. The average body mass index (BMI)

and thyroid-stimulating hormone (TSH) levels were 25.56 ± 3.25 and 2.19 ± 1.01, respectively, for women with adverse pregnancy outcomes, and 25.59 ± 3.75 and 2.5 ± 1.1, respectively, for those with live birth outcomes.

Table 3: Mean and standard deviation of demographic and anthropometric characteristics, as well as years of infertility, categorized by pregnancy outcomes in women with successful IVF.

Variable	Pregnancy outcomes		p-value	test
	Live birth (90 people)	Adverse outcome (47 people)		
	Standard deviation ± mean	Standard deviation ± mean		
Age (years)	34.31 ± 5.9	34.37 ± 6.5	0.887	t-test
Body Mass Index	25.59 ± 3.75	25.56 ± 3.25	0.972	t-test
Thyroid Stimulating Hormone	2.5 ± 1.1	2.19 ± 1.01	0.125	t-test
Years of primary infertility	4.87 ± 3.29	5.54 ± 4.1	0.365	t-test
Years of secondary infertility	4.44 ± 2.25	4.43 ± 2.14	0.993	t-test

Additionally, the mean duration of primary infertility was 5.54 ± 4.1 years for women with adverse pregnancy outcomes and 4.87 ± 3.29 years for those with live birth outcomes. Similarly, the mean duration of secondary infertility was 4.43 ± 2.14 years and 4.44 ± 2.25 years, respectively, in the two groups.

Statistical analysis using a t-test indicated no significant differences between women with adverse pregnancy outcomes and those with live birth outcomes in terms of age, BMI, TSH levels, or the duration of primary and secondary infertility ($p > 0.05$).

According to Table **4**, a comparison of women's underlying conditions revealed that 21.1% of women with live birth outcomes and 27.7% of those with adverse pregnancy outcomes had hypothyroidism, a difference that was not statistically significant.

Table 4: Comparison of hypothyroidism, duration of primary and secondary infertility, varicocele, and varicocelectomy based on pregnancy outcomes in couples with successful IVF.

Variable	Pregnancy outcomes		p-value	test
	Live birth (90 people)	Adverse outcome (47 people)		
Hypothyroidism	21.1%	27.7%	0.390	Chi-square
Primary infertility	78.9%	72.3%	0.000	Chi-square
Secondary infertility	16.7%	12.8%	0.001	Chi-square
Varicocele	21.1%	10.6%	0.042	Chi-square
Varicocelectomy	6.7%	19.1%	0.042	Chi-square

In terms of spouses' underlying conditions, 21.1% of the spouses of women with live birth outcomes had varicocele, with 6.7% having undergone varicocelectomy. In contrast, 10.6% of the spouses of women with adverse pregnancy outcomes had varicocele, with 19.1% having undergone varicocelectomy. This difference was statistically significant.

Additionally, 78.9% of women with live birth outcomes and 72.3% of those with adverse pregnancy outcomes had primary infertility. Meanwhile, 16.7% of women with live birth outcomes and 12.8% of those

with adverse pregnancy outcomes had secondary infertility. These differences were also statistically significant ($p < 0.05$).

4. Discussion

The aim of this study was to investigate and compare the relationship between TSH levels and BMI with the success or failure of IVF/ICSI treatments and pregnancy outcomes in infertile women. The results showed no statistically significant differences between women with successful and unsuccessful IVF, nor between those with adverse pregnancy outcomes and live birth outcomes, in terms of age, BMI, TSH levels, hypothyroidism, or the duration of primary and secondary infertility.

These findings align with those of Legge et al. (2014), who conducted a study in France on 752 women undergoing treatment. Their research revealed that higher BMI values did not significantly influence clinical outcomes of IVF treatments [24]. Similarly, a systematic review and meta-analysis of 842 articles demonstrated that even significant weight loss prior to IVF did not improve live birth rates in overweight women [25]. These conclusions are consistent with the findings of the present study.

Additionally, Ozekinci et al. (2015) conducted a retrospective study on 298 women under 35 years of age undergoing IVF/ICSI and concluded that, while obese women required higher doses of gonadotropins and longer stimulation durations, obesity did not significantly affect pregnancy outcomes [26]. These results, along with those from several other studies, also align with the findings of this study [27].

In contrast, a study by Dan Liu et al. (2018–2021) in Shanghai reported a significant relationship between BMI and pregnancy outcomes resulting from ART techniques in women aged 30–38. However, this relationship was not observed in younger or older women [28].

Regarding TSH levels, Reh et al. (2005–2008) in the United States observed that while lowering the TSH threshold increased the number of women diagnosed with hypothyroidism, this reduction did not affect clinical pregnancy or abortion rates. Similarly, a meta-analysis by Zhoa et al. indicated that TSH values of 2.5 mIU/L do not significantly influence ART outcomes, whereas TSH levels between 3.5 and 5 mIU/L significantly increase abortion rates [29]. In the current study, the average TSH levels were 2.19 ± 1.01 in women with adverse pregnancy outcomes and 2.5 ± 1.1 in women with live birth outcomes, both below the threshold associated with increased abortion rates.

A study by Lintens et al. on 4,928 IVF/ICSI candidate couples found no significant relationship between infertility duration and IVF outcomes [30], consistent with the findings of the present study. However, Templeton et al. reported a significant difference in IVF outcomes for women with infertility durations exceeding 13 years [31]. This discrepancy might be related to the shorter infertility duration in the current study (<10 years), where no significant differences were observed between successful and unsuccessful IVF groups.

The findings also revealed that a higher percentage of women with successful IVF and live birth outcomes had secondary infertility, whereas a higher percentage of women with unsuccessful IVF and adverse pregnancy outcomes had primary infertility. This difference was statistically significant and aligns

with the findings of Eijkemans et al., who examined pregnancy chances in cases of primary and secondary infertility [32]. Other studies, including that of Jacobs et al. [33], also identified significant relationships between infertility type (primary or secondary) and live birth outcomes, consistent with the present study.

Lastly, comparing spouses' underlying conditions revealed that a higher percentage of spouses of women with successful IVF and live birth outcomes had varicocele, while a higher percentage of spouses of women with unsuccessful IVF and adverse pregnancy outcomes had undergone varicocelectomy. These findings may relate to varicocele severity (graded 1 to 3), as studies suggest that severe varicoceles, even after surgery, can negatively affect fertility and pregnancy outcomes, unlike mild varicoceles managed without surgical intervention [34].

5. Conclusion

In this study, no significant differences were observed in BMI, TSH levels, years of primary or secondary infertility, or hypothyroidism between women with adverse pregnancy outcomes and those with live birth outcomes. Additionally, BMI, TSH levels, years of infertility, and hypothyroidism were not significantly correlated with IVF success or failure. However, some studies have reported findings that contradict those of this study. One notable difference is that the current study examined a larger statistical population, with samples collected from various centers and regions.

This study found that a higher percentage of women with unsuccessful IVF outcomes had primary infertility, while a higher percentage of women with successful IVF outcomes had secondary infertility. Similarly, women with adverse pregnancy outcomes were more likely to have primary infertility, whereas those with live birth outcomes were more likely to have secondary infertility. These differences were statistically significant in both groups.

Furthermore, an analysis of the spouses' underlying conditions revealed significant differences. In the group of women with successful IVF outcomes, a higher percentage of spouses had varicocele, and a lower percentage had undergone varicocelectomy, compared to the unsuccessful IVF group. Similarly, in the group of women with live birth outcomes, a higher percentage of spouses had varicocele, and a lower percentage had undergone varicocelectomy, compared to the group with unfavorable outcomes. These differences were also statistically significant and may be linked to the severity of varicocele grades, as more severe cases may negatively impact fertility and pregnancy outcomes, even after surgical intervention.

Declarations

Ethics approval and consent to participate

The Medical Ethics Committee of Shiraz University of Medical Sciences approved this study with the reference number IR.SUMS.MED.REC.1400.428. All participants have signed the informed consent form.

Consent for publication

Not applicable.

Availability of data and material

The research data associated with this paper will be available upon request.

Competing interests

The authors state no conflict of interest.

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Author contributions

B.NJ. designed the research theme. Z.M. executed the research process. S.S. analyzed the data. S.S., F.D. and Z.E. wrote the manuscript. The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

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