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Original Research Article

Correlation between body mass index and serum anti-Mullerian hormone level in subfertile women at BIRDEM General Hospital, Dhaka

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ABSTRACT

Background: Anti-Mullerian hormone (AMH) is a crucial marker for ovarian reserve, reflecting ovarian function due to its secretion by antral follicles. Obesity can adversely affect fertility, potentially altering AMH production. The aim of this study was to assess the correlation between body mass index (BMI) and serum anti-Mullerian hormone (AMH) level in subfertile women.
Methods: This cross-sectional analytical study was carried out in the department of obstetrics and gynecology, BIRDEM General Hospital, Dhaka, over a period of 18 months from January 2023 to June 2024.
Results: Between BMI≥25 kg/m^2 and <25 kg/m^2 groups there were no significant differences in age distribution (mean ages: 30.5 versus 30.4 years, p=0.912). There were no significant differences in education, occupation, or income distribution between two groups. Menstrual regularity and flow differed significantly, with more irregular cycles and heavier flow in the BMI≥25 group (p<0.0001 and p=0.049, respectively). Serum AMH levels were significantly lower in the BMI≥25 group (1.7 versus 3.1, p<0.0001). A negative correlation was found between serum AMH levels and BMI, indicated that serum AMH level decreases with increasing BMI (p<0.0001). Age and BMI were inversely significantly associated with serum AMH level adjusted for each other.
Conclusions: Higher BMI was associated with lower serum AMH levels in subfertile women, suggesting that elevated BMI may negatively impact serum AMH level which is a potential marker of ovarian reserve.

Keywords: Anti-Müllerian hormone, Body mass index, Obesity, Ovarian reserve, Reproductive health, Subfertility

INTRODUCTION

Anti-Mullerian hormone (AMH) belongs to the transforming growth factor beta family, generated primarily by granulosa cells within small, developing follicles. Its role involves impeding the initial recruitment of follicles and the FSH-driven expansion of pre-antral and small antral follicles within the ovaries. AMH suppresses the activation of primordial follicles, and serum levels of AMH correlate with the quantity of developing follicles, suggesting its potential as a marker for ovarian reserve.[1] Since AMH is exclusively secreted from ovarian follicles

its serum concentration is thought to reflect the size of ovarian follicular pool. As serum AMH levels show less variation throughout the ovarian cycle, measuring AMH has become commonly utilized for assessing ovarian reserve, particularly in infertility cases.[2]

Anti-Müllerian hormone (AMH) plays a crucial role in the natural regression of the Mullerian ducts during sexual differentiation in male fetuses. In females, AMH is primarily produced by small antral follicles within the ovaries, acting as both an autocrine and paracrine regulator of follicular development. Since the size of the remaining follicular pool is contingent upon the quantity of small antral follicles and diminishes with time, the trajectory of serum AMH levels in women typically involves a gradual decrease throughout their reproductive years, followed by a significant decline at menopause. Consequently, AMH holds clinical value as a screening tool for assessing diminished ovarian reserve.[3]

Alterations in serum AMH levels have been associated with various pathological & biological conditions. For instance, in polycystic ovary syndrome (PCOS), there's an excess of follicles that produce elevated levels of AMH, establishing a pathophysiological connection. In the realm of assisted reproductive technology (ART), serum AMH assays are commonly utilized to provide prognostic insights, including the likelihood of successful ovarian stimulation, subsequent embryo quality, and even pregnancy rates.[4]

The secretion of anti-Müllerian hormone (AMH) by the ovaries and its plasma levels exhibit age-related patterns. The highest concentrations of AMH are typically observed during puberty. Subsequently, they gradually decline starting from around the age of 25 years, becoming notably lower during the premenopausal period, and ultimately undetectable after menopause. Furthermore, studies have revealed that in individuals with polycystic ovaries, the production of AMH by granulosa cells is significantly elevated compared to normal ovaries. Consequently, it has been proposed that AMH levels serve as a marker for the severity of ovulatory disturbances in PCOS.[5]

Certain conditions can influence serum AMH levels. Obesity, for instance, has been identified as a factor that may decrease serum AMH levels, a phenomenon initially noted among women of advanced reproductive age.[6] Obesity is an enduring and growing public health challenge. In the last three decades, the average body mass index (BMI) has risen in developing countries.[7] The prevalence of overweight and obesity rose by 8.8% and 29.9% in 2017-2018 BDHS and was 24% in 2014 BDHS.[8,9]

Objective

The objective of this study was to assess the correlation between body mass index (BMI) and serum anti-Mullerian hormone (AMH) level in subfertile women.

METHODS

This cross-sectional analytical study was carried out in the department of obstetrics and gynecology, BIRDEM General Hospital, Dhaka, over a period of 18 months from January 2023 to June 2024, following approval from the institutional review board, and the study population comprised subfertile women who attended the department for treatment of subfertility. A total of 122 subfertile women were recruited using purposive sampling from those attending the outpatient and inpatient services for evaluation and treatment of subfertility. Subfertility was defined as the inability to conceive after at least one year of regular unprotected intercourse.

Women with a history of ovarian surgery, chemotherapy, radiotherapy, known endocrine disorders such as thyroid dysfunction, hyperprolactinemia, or Cushing's syndrome, and those currently on hormonal treatment were excluded from the study. After applying the inclusion and exclusion criteria, eligible participants were enrolled and written informed consent was obtained.

All participants underwent a detailed interview and clinical evaluation. Socio-demographic data, obstetric and menstrual history, and relevant clinical features were recorded in a structured data collection form. Anthropometric measurements were taken with standard procedures, where height was measured in centimeters using a stadiometer and weight in kilograms with a calibrated weighing scale. Body mass index (BMI) was calculated by dividing body weight in kilograms by the square of height in meters and categorized according to World Health Organization guidelines. Based on BMI, the study population was divided into two groups: group I consisting of women with BMI≥25 kg/m^2 and group II consisting of women with BMI<25 kg/m^2, with 61 women in each group.

For biochemical analysis, 5 ml of venous blood was collected from each participant under aseptic conditions during the early follicular phase of the menstrual cycle (day 2-4). Serum was separated and stored appropriately until analysis. Serum anti-Müllerian hormone (AMH) levels were measured using a commercially available enzyme-linked immunosorbent assay (ELISA) kit, following manufacturer's instructions, and results were expressed in ng/ml. All assays were carried out in the same laboratory to ensure consistency.

Collected data were compiled and entered into SPSS version 26 for analysis. Descriptive statistics were applied to summarize socio-demographic and clinical characteristics. Independent sample t-tests and chi-square tests were used for comparison between groups, while Pearson's correlation and regression analysis were performed to assess the relationship between BMI and serum AMH levels. A p value of <0.05 was considered statistically significant.

RESULTS

Table 1 revealed that in both BMI groups, the age distribution was quite similar. Specifically, in BMI≥25 kg/m^2 group, 19.7% were aged 15 to 24 years, 55.7% were aged 25 to 34 years, and 24.6% were aged 35 to 44 years and above. In BMI<25 kg/m^2 group, 11.5% were aged 15 to 24 years, 67.2% were aged 25 to 34 years, and 21.3% were aged 35 to 44 years and above. There was no statistically significant difference between BMI groups in term of age distribution. The mean age in BMI≥25 group was 30.5 years with a standard deviation of 5.4, and in BMI<25 group, the mean age was 30.4 years with a standard deviation of 4.3. The p values indicated no significant difference between the two groups in terms of mean age (p=0.912).

Table 1: Distribution of the participants according to age by BMI groups.

Age (in years)	BMI≥25 kg/m^2 (n=61)	BMI<25 kg/m^2 (n=61)	P value
15 to 24	12 (19.7)	7 (11.5)	
25 to 34	34 (55.7)	41 (67.2)	0.345[a]
35 to 44 and above	15 (24.6)	13 (21.3)	
Mean±SD	30.5±5.4	30.4±4.3	0.912[c]

[a]Chi square test was done to observe association between variables, [c] unpaired t test was done to compare Mean±SD
Figure within parentheses ( ) indicated percentage.

Table 2: Comparison of the participants according to menstrual history by two BMI groups.

Menstrual history	BMI≥25 kg/m^2 (n=61)	BMI<25 kg/m^2 (n=61)	P value
Menstrual flow			
Scanty	16 (26.2)	13 (21.3)	
Average	38 (62.3)	47 (77.0)	0.049[b]
Heavy	7 (11.5)	1 (1.6)	
Dysmenorrhea			
Present	10 (16.4)	11 (18.0)	0.810[a]
Absent	51 (83.6)	50 (82.0)	
Menstrual period in days (Mean±SD)	5.13±1.9	5.28±1.7	0.655[c]

[a]Chi square test and [b] Fisher's Exact were done to observe association between variables, [c] unpaired t test was done to compare Mean ± SD Figure within parentheses ( ) indicated percentage.

Table 3: Comparison of the participants according to obstetric and ovulation induction history by two groups.

Obstetric history	BMI≥25 kg/m^2 (n=61)	BMI<25 kg/m^2 (n=61)	P value
Type of subfertility			
Primary	20 (32.8)	40 (65.6)	<0.0001 [a]
Secondary	41 (67.2)	21 (34.4)	
Ovulation induction drug			0.363[a]
Taken	30 (49.2)	25 (41.0)	
Not taken	31 (50.8)	36 (59.0)	

[a]Chi square test was done to observe association between variables. Figure within parentheses ( ) indicated percentage.

Figure 1 showed that among individuals with a BMI≥25 kg/m^2, 41.0% had a regular menstrual cycle and 59.0% had an irregular cycle. Among those with a BMI<25 kg/m^2, 83.6% had a regular menstrual cycle and 16.4% had an irregular cycle, with a significant difference (p<0.0001).

Table 2 showed that in BMI≥25 kg/m^2 group (n=61), 26.2% had scanty flow, 62.3% had average flow, and 11.5% had heavy flow. In BMI<25 kg/m^2 group (n=61), 21.3% had scanty flow, 77.0% had average flow, and 1.6% had heavy flow, with a p value of 0.049 indicating a significant difference. Dysmenorrhea was present in 16.4% of BMI≥25 kg/m^2 group and 18.0% of BMI<25 kg/m^2 group, with no significant difference (p=0.810). The average menstrual period was 5.13±1.9 days for BMI≥25 group and 5.28±1.7 days for BMI<25 group, with no significant difference (p=0.655).

Table 3 showed that regarding the obstetric history, In BMI≥25 kg/m^2 group (n=61), 32.8% women were experiencing primary subfertility and 67.2% secondary subfertility, whereas in BMI<25 kg/m^2 group (n=61), 65.6% women were experiencing primary subfertility and 34.4% secondary subfertility, indicating a significant

difference (p<0.0001). Regarding the usage of ovulation induction drugs, 49.2% women of BMI≥25 kg/m^2 group and 41.0% of BMI<25 kg/m^2 group had taken them, with no significant difference (p=0.363), while 50.8% of BMI≥25 kg/m^2 group and 59.0% of BMI<25 kg/m^2 group had not taken them.

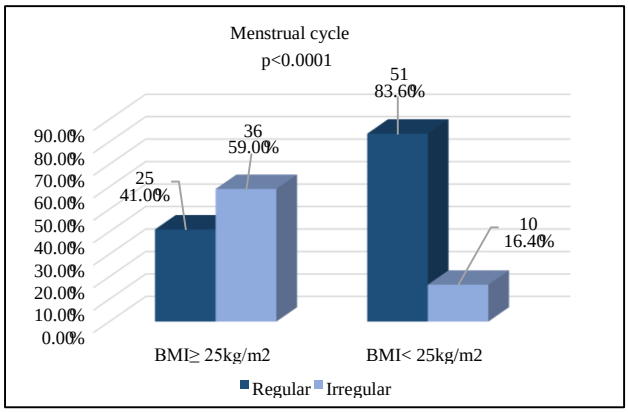

Figure 1: Comparison of the participants according to menstrual cycle by two groups.

Table 4 showed BMI≥25 kg/m^2 group (n=61) had a mean height of 150.2±6.3 cm and BMI<25 kg/m^2 group had 154.8±5.8 cm, with a significant difference (p<0.0001). Similarly, BMI≥25 kg/m^2 group had a mean weight of 65.8±8.6 kg, which was significantly different from BMI<25 kg/m^2 group had mean weight of 55.2±4.8 kg (p<0.0001). However, there were no significant differences between the groups in terms of waist circumference (p=0.940). The hip circumference was 99.9±4.9 cm in BMI≥25 kg/m^2 group and 96.4±4.3 cm BMI<25 kg/m^2 group, with a significant difference (p<0.0001). Additionally, the waist-hip ratio was 0.8±0.1 in BMI≥25 kg/m^2 group and 0.7±0.1 in BMI<25 kg/m^2 group, showed a significant difference (p<0.0001).

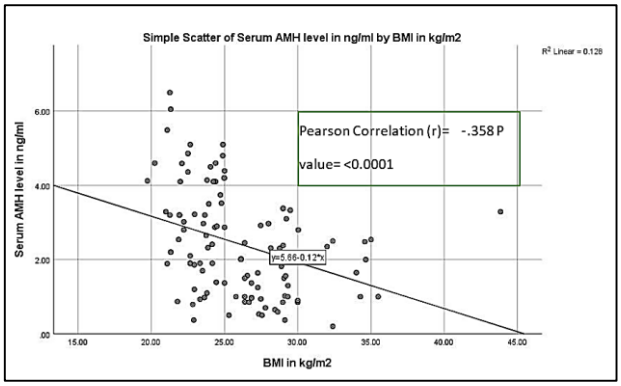

Figure 2: Correlation between serum AMH level and BMI.

This scattered plot showed a negative correlation between serum AMH level and BMI which indicated that serum AMH level decreases with increasing BMI.

Table 4: Comparison of the participants according to height, weight, waist circumference, hip circumference, waist-hip ratio by two BMI groups.

Parameters (Mean±SD)	BMI≥25 kg/m^2 (n=61)	BMI<25 kg/m^2 (n=61)	P value
Height (cm)	150.2±6.3	154.8±5.8	<0.0001[c]
Weight (kg)	65.8±8.6	55.2±4.8	<0.0001[c]
Waist circumference (cm)	88.9±8.4	88.1±8.2	0.940[c]
Hip circumference (cm)	99.9±4.9	96.4±4.3	<0.0001[c]
Waist-hip ratio	0.8±0.1	0.7±0.1	<0.0001[c]

[c] unpaired t test was done to compare Mean±SD.

Table 5: Comparison of participants of BMI≥25 kg/m^2 according to serum AMH levels by age groups in subfertile women.

Serum AMH level (ng/ml)	Age (15-24 years)	Age (25-34 years)	Age (35-≥44 years)	P value
Mean±SD	2.8±1.1	1.7±0.9	1.0±0.5	<0.0001[d]

[d] One-way ANOVA test was done to compare Mean±SD.

Table 6: Comparison of participants of BMI<25 kg/m^2 according to serum AMH levels by age groups in subfertile women.

Serum AMH level (ng/ml)	Age (15-24 years)	Age (25-34 years)	Age (35-≥44 years)	P value
Mean±SD	4.6±1.8	2.8±1.8	2.8±1.2	0.028[d]

[d] One-way ANOVA test was done to compare Mean±SD.

Table 7: Multiple linear regression analysis for factors predicting serum AMH level coefficients[a].

Variables	Unstandardized coefficients (b)	SE	Standardized coefficients (β)	t	P value	95% CI for b
Constant	10.104	1.29	–	7.86	0	7.560 to 12.649
Age in years	-0.138	0.028	-0.398	-4.97	0	-0.193 to -0.083
BMI (kg/m^2)	-0.135	0.034	-0.314	-3.915	0	-0.203 to -0.066

[a]Dependent variable: AMH (ng/ml).

Table 5 showed comparison of the serum AMH levels in subfertile women with a BMI≥25 kg/m^2 across different age groups, showed mean±SD values of 2.8±1.1 for ages 15-24 years, 1.7±0.9 for ages 25-34, and 1.0±0.5 for ages 35->44, with a p value of <0.0001[d] indicated statistically significant difference.

Table 6 showed comparison of the serum AMH levels in subfertile women with a BMI<25 kg/m^2 across different age groups, showed mean±SD values of 4.6±1.8 for ages 15-24, 2.8±1.8 for ages 25-34, and 2.8±1.2 for ages 35->44, with a p value of 0.028 indicated statistically significant difference.

The multiple linear regression analysis model showed that age and BMI were inversely significantly associated with serum AMH level adjusted for each other. The model was significant (F=18.79, p<0.001), age showed a negative association with AMH (β=0.398, p<0.001), indicated that AMH decreases by 0.398 points for each year of age increase. BMI also had a significant negative effect (β=-0.314, p<0.001) on AMH, that AMH decreases by 0.314 points for each unit increase in BMI. Together, age and BMI explained 47.7% of the variance in AMH levels, demonstrating their significant role in influencing serum AMH level (Table 7).

DISCUSSION

Obesity is a complex condition with wide-ranging effects on the body, including the reproductive system. An increased BMI can impair reproductive function, affecting everything from folliculogenesis to embryo development and implantation. This study was done to find out the correlation between body mass index (BMI) and serum anti Mullerian HORMONE (AMH) levels in subfertile women. There were 122 subfertile women in this study among them group I with BMI≥25 kg/m^2 and group II with BMI<25 kg/m^2, each group was consisted of 61 subfertile women. The results presented several findings regarding the demographic, socio-economic, and clinical characteristics of the participants and their correlation with BMI and serum AMH levels.

The study showed that the age distribution between the two BMI groups was similar. In BMI≥25 kg/m^2 group, 19.7% were aged 15 to 24 years, 55.7% were aged 25 to 34 years, and 24.6% were aged 35-≥44 years. In BMI<25 kg/m^2 group, 11.5% were aged 15 to 24 years, 67.2% were aged 25 to 34 years, and 21.3% were aged 35-≥44 years. The chi-square test found no significant difference in age distribution between the groups (p=0.345). This similarity was crucial, ensuring that differences in serum AMH levels were due to BMI and not age difference. Thus, the study reliably indicates that higher BMI is associated with lower serum AMH levels, independent of age. Nelson et al, noted that serum AMH levels decline with age, highlighting the importance of considering age in reproductive studies.[10] The comparable age distribution in both BMI groups in this study ensures that the observed effects of BMI on serum AMH levels are not influenced by age differences.[10]

Present study revealed a significant difference in menstrual cycle regularity between individuals with BMI≥25 kg/m^2 and those with BMI<25 kg/m^2. Specifically, 41.0% of participants with BMI≥25 kg/m^2 experienced regular menstrual cycles, contrasting with 59.0% who had irregular cycles. In comparison, among those with BMI<25 kg/m^2, 83.6% reported regular menstrual cycles, while 16.4% had irregular cycles. This disparity between the two BMI groups was statistically significant (p<0.0001). The observed association between BMI and menstrual cycle regularity aligns with research linking higher BMI to menstrual irregularities and reproductive health complications.[11] Elevated BMI can disrupt hormonal balance, potentially leading to irregular menstrual patterns due to alterations in estrogen and progesterone levels.[12] Additionally, adipose tissue, particularly in individuals with higher BMI, can contribute to increased production of estrogen, which may further affect menstrual cycle regularity.[11]

The data in present study indicated that the serum AMH level was significantly lower in the BMI≥25 kg/m^2 group compared to the BMI<25 kg/m^2 group (p<0.0001). This significant difference suggests that higher BMI may negatively impact ovarian reserve. Significant differences were observed in height, weight, hip circumference, and waist hip ratio, with higher values in the BMI≥25 group (p<0.0001), while waist circumference showed no significant difference (p=0.940). This study showed a negative correlation between serum AMH level and BMI which indicated that serum AMH level decreases with increasing BMI. Research has shown that increased body fat can disrupt hormonal balance, potentially leading to lower AMH levels and reduced fertility. Moy et al, in their study found that BMI and AMH were negatively

correlated among Caucasian women, but this relationship was not observed among African American, Asian American, and Hispanic women.[13] This result might be due to genetic, hormonal, and lifestyle differences across ethnic groups that influence how BMI affects ovarian reserve and AMH levels. Another study found that obese women had lower AMH levels compared to non-obese women. Over an eight-year longitudinal analysis, it was consistently observed that women with higher BMI had lower AMH levels than those with normal BMI. This difference is likely due to the negative impact of excess body fat on hormonal balance, which can impair ovarian function and reduce AMH levels which supports the findings of present study.[14,15] Another study using a multivariate linear regression model found an association between BMI and AMH, with BMI being a significant predictor (beta 0.059, p=0.004).[16]

In the present study, the serum AMH levels in subfertile women with a BMI≥25 kg/m^2 varied significantly across different age groups, showed mean±SD values of 2.8±1.1 for ages 15-24 years, 1.7±0.9 for ages 25-34, and 1.0±0.5 for ages 35-≥44, with a p value of <0.0001[d] indicated statistically significant difference. Conversely, in subfertile women with a BMI<25 kg/m^2, the mean serum AMH levels showed 4.6±1.8 for ages 15-24, 2.8±1.8 for ages 25-34, and 2.8±1.2 for ages 35-≥44, with a p value of 0.028 indicated statistically significant difference. This finding might be due to the association between higher BMI and reduced ovarian reserve, which leads to lower AMH levels. This relationship is more pronounced in women with higher BMI, significantly affecting AMH levels across different age groups. In contrast, women with a lower BMI might maintained more stable AMH levels irrespective of age, indicated better ovarian reserve and reproductive potential. But the multiple linear regression analysis model showed significant relationship of BMI and age with serum AMH level. The model was significant ($F=18.79$, $p<0.001$), age showed a negative association with AMH ($\beta=-0.398$, $p<0.001$), indicated that AMH decreases by 0.398 points for each year of age increase. BMI also had a significant negative effect ($\beta=-0.314$, $p<0.001$) on AMH, that AMH decreases by 0.314 points for each unit increase in BMI. Bernardi et al, in their study revealed that participants who were obese at both age 18 and at the time of the study had much lower AMH levels compared to those who were a normal weight at age 18, suggesting that longer duration of obesity can worsen its impact on AMH levels which was consistent with the findings of present study.[17,18]

The limited sample size from a single hospital may not represent the broader population, restricting the generalizability of the findings. The study's cross-sectional nature provided a single time-point analysis, making it difficult to establish interrelationship between BMI and serum AMH level. Despite controlling for age and socio-economic factors, other confounding variables like lifestyle, diet, physical activity, and health conditions might influence the results.

CONCLUSION

The study found that, higher BMI was significantly associated with lower serum AMH levels. Despite similar age distributions, BMI≥25 kg/m^2 was linked to irregular menstrual cycles and lower AMH levels across all age groups, while BMI<25 kg/m^2 maintained more stable AMH levels. These findings highlight the importance of weight management in reproductive health and suggest BMI as a critical factor influencing ovarian reserve in subfertile women.

Recommendations

Further studies may be conducted including a larger, multi-centered sample to enhance the generalization and to validate the findings across different populations. Conduction of longitudinal research to clarify the causal relationship between BMI and serum AMH levels over time. Incorporation of detailed assessments of lifestyle, diet, physical activity, and health conditions to isolate BMI's specific impact on serum AMH levels.

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