Section: Physiology

Original Research Article

ASSOCIATION BETWEEN BODY MASS INDEX AND SERUM ESTRADIOL LEVELS IN POSTMENOPAUSAL WOMEN: ENDOCRINE PERSPECTIVES

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ABSTRACT

Background: In postmenopausal women, the substantial decline in ovarian estrogen production leads to a reliance on peripheral conversion of androgens to estrogens in adipose tissue as the primary source of circulating estrogen. Body mass index (BMI), as a surrogate marker of adiposity, may influence estradiol concentrations and consequently alter the endocrine profile in this population. **Objective:** This study aimed to evaluate the association between BMI and serum estradiol levels in asymptomatic postmenopausal women and to explore the potential endocrine implications of this relationship. **Materials and Methods:** A cross-sectional analysis was conducted on 60 asymptomatic postmenopausal women aged 45 – 60 years. BMI was calculated based on measured height and weight. Serum estradiol levels were measured using the enzyme-linked immunosorbent assay (ELISA) method. Participants were stratified according to BMI categories based on the World Health Organization (WHO) and Indian Council of Medical Research (ICMR) Asian classification criteria. Correlation analysis was performed using SPSS 24 to assess the relationship between BMI and serum estradiol levels. **Result:** A statistically significant positive correlation was observed between BMI and serum estradiol levels ($p < 0.05$). Women in the overweight and obese categories exhibited higher serum estradiol concentrations compared to those with normal BMI. These findings support the hypothesis that increased adiposity contributes to elevated circulating estrogen levels via peripheral conversion of androgens. **Conclusion:** The findings suggest that BMI may be an important modulator of estradiol levels in postmenopausal women, potentially influencing their endocrine and metabolic profiles. These endocrine alterations may have important implications for the risk of estrogen-dependent conditions such as endometrial hyperplasia and carcinoma. Monitoring BMI and estradiol levels may enhance risk stratification and preventive strategies in post-menopausal care.

INTRODUCTION

Menopause marks the end of a woman's reproductive years. It is characterized by the permanent cessation of ovarian function, accompanied by a substantial decline in circulating estrogenlevels.[1] Of the three major forms of estrogen - estrone (E1), estradiol (E2), and estriol (E3). The estradiol (E2) is the most biologically potent during the reproductive years.[2] However, its production decreases sharply following menopause due to ovarian atrophy.

In postmenopausal women, the primary source of estrogen shifts from ovarian secretion to the extragonadal aromatization of androgens into estrogens. The enzyme aromatase primarily mediates this process. The enzyme aromatase is highly active in adipose tissue, making body fat a significant source of estrogen in the absence of ovarian function. As a result, body mass index (BMI), an indirect measure of adiposity, becomes a key determinant of serum estradiol levels in postmenopausal women.[3]

Increased adiposity not only enhances peripheral estrogen production but also suppresses the

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synthesis of sex hormone-binding globulin (SHBG), thereby elevating the levels of free, biologically active estradiol. [4] These hormonal alterations have important clinical implications, particularly in relation to the risk of estrogen-sensitive conditions such as endometrial hyperplasia, endometrial carcinoma, and breast cancer.

Understanding the relationship between BMI and serum estradiol levels in postmenopausal women is essential for evaluating their endocrine health and formulating individualized preventive strategies. Although previous studies have established a link between obesity and altered estrogen levels, limited data focus on asymptomatic postmenopausal women, especially within the South Asian population.

This study aims to investigate the association between BMI and serum estradiol levels in asymptomatic postmenopausal women and to explore the underlying endocrine mechanisms and potential clinical consequences of this relationship.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional, observational study was conducted over 12 months at a tertiary care institute in Chennai, India. Ethical approval was obtained from the Institutional Ethics Committee before the commencement of the study.

A total of 60 asymptomatic postmenopausal women, aged between 45 and 60 years, were enrolled. Participants were recruited from the Non-Communicable Diseases (NCD) outpatient clinic of the institute.

Menopause was defined as the absence of menstruation for at least 12 consecutive months, not attributable to any pathological or physiological cause other than natural ovarian aging.

Inclusion Criteria

Participants were eligible for the study if they met all of the following criteria:

- Women aged between 45 and 60 years.
- History of at least 12 months of amenorrhea.
- Absence of postmenopausal bleeding.
- Not currently receiving hormone replacement therapy.

Exclusion Criteria

Participants were excluded if they had any of the following:

- History of postmenopausal bleeding.
- History of hysterectomy or oophorectomy.
- Known endocrine disorders (e.g., diabetes mellitus, thyroid disease).
- History of malignancy or endometriosis.
- Presence of chronic inflammatory diseases.

Data Collection and Measurements

Anthropometric Assessment:

All participants underwent a general physical examination. Height was measured in centimetres using a calibrated stadiometer, and weight was recorded in kilograms using a standardized electronic weighing scale.

Body mass index (BMI) was calculated using the formula: BMI = Weight (kg) / Height (m^2). BMI categories were classified according to the guidelines of the World Health Organization (WHO) and the Indian Council of Medical Research (ICMR) for South Asian populations.

Serum Estradiol Estimation

Under aseptic conditions, 5 mL of venous blood was collected from each participant. Samples were centrifuged at 3000 rpm for 10 minutes to separate the serum, which was then stored at -20°C until analysis. Serum estradiol (E2) levels were measured using a solid-phase sandwich enzyme-linked immunosorbent assay (ELISA) specific for estradiol. Absorbance was read at 450 nm using a microplate reader, and results were expressed in picograms per millilitre (pg/mL).

Statistical Analysis

Data were analyzed using SPSS version 24

1. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were calculated for height, weight, BMI, and serum estradiol levels.
2. Pearson's correlation coefficient was used to evaluate the relationship between BMI and serum estradiol levels in asymptomatic postmenopausal women.

A p-value of <0.05 was considered statistically significant.

RESULTS

Participant Characteristics

A total of 60 asymptomatic postmenopausal women aged between 45 and 60 years were included in the study. The mean age of the participants was 53.6 ± 4.2 years, with an average duration since menopause of 6.4 ± 2.1 years. The mean body mass index (BMI) was 26.3 ± 3.5 kg/m^2, indicating that the majority of the women were classified as overweight or obese according to ICMR-Asian criteria.

BMI Distribution

- **Normal BMI** (18.5–22.9 kg/m^2): 18 women (30%)
- **Overweight** (23.0–24.9 kg/m^2): 12 women (20%)
- **Obese** (≥25.0 kg/m^2): 30 women (50%)

Serum Estradiol Levels

The mean serum estradiol level among participants was 31.2 ± 11.6 pg/mL. Notably, estradiol levels were significantly higher in the obese group compared to those with a normal BMI ($p < 0.05$).

Correlation Analysis

A Pearson correlation analysis demonstrated a statistically significant positive correlation between BMI and serum estradiol levels ($r = 0.53$, $p = 0.001$), indicating that higher BMI is associated with

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elevated estradiol concentrations in postmenopausal women.

Table 1: Mean Serum Estradiol and its Significance with BMI distribution

BMI Category	N	Mean Estradiol (pg/mL)	p-value
Normal	18	21.5 ± 6.8	0.034
Overweight	12	29.3 ± 8.4	0.031
Obese	30	37.1 ± 10.2	0.001

Graphical Representation

A scatter plot was generated to visually represent the relationship between BMI and serum estradiol levels. A linear upward trend line confirms the positive correlation.

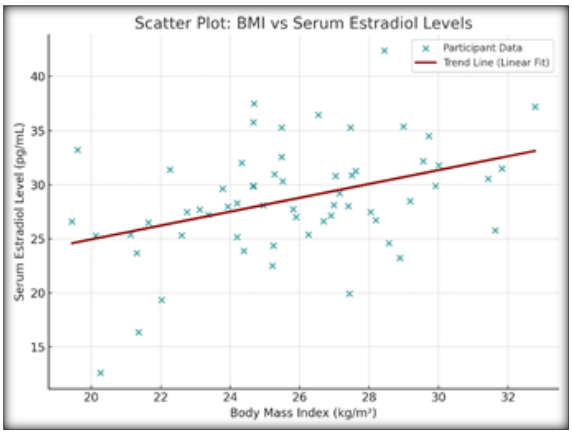

Figure 1: Scatter plot: BMI vs Serum Estradiol Levels

DISCUSSION

This study examined the relationship between body mass index (BMI) and serum estradiol levels in asymptomatic postmenopausal women in South India. The findings demonstrated a statistically significant positive correlation. Serum estradiol level in asymptomatic postmenopausal women increases as BMI increases. This supports the hypothesis that adiposity plays a key role in determining the estrogen level after menopause.

In postmenopausal women, the primary source of estrogen production will be the peripheral conversion of androgens into estrogens and not the ovaries as in the reproductive age group. This conversion primarily occurs through the action of the enzyme aromatase in adipose tissue.[5,6] This process becomes particularly relevant in obese individuals, in whom increased fat mass offers a larger substrate and enzymatic capacity for estrogen biosynthesis. Our present study's results are consistent with this biological model, aligning with the previous literature that links obesity to elevated estradiol levels in postmenopausal women.[7,8]

According to Burger et al. Serum sex hormone binding globulin (SHBG) levels fall to a small degree during the postmenopausal period.[9] As obesity is associated with a decrease in SHBG levels, further exacerbates this decline, increasing the proportion of free, biologically active estradiol.[10-12] This dual mechanism—enhanced aromatization and reduced hormonal binding—contributes to the elevated estradiol concentrations observed in women with higher BMI. Moreover, hyperinsulinemia due to insulin resistance seen in obesity suppresses SHBG synthesis, which also contributes to this effect.[8] Although these hormonal changes are physiologically derived, they are not necessarily benign. Elevated estradiol levels, particularly in the absence of opposing progesterone, are implicated in the pathogenesis of estrogen-dependent disorders, including endometrial hyperplasia and carcinoma.

Allen et al. reported that high levels of free testosterone and estrogens were associated with an increased risk of endometrial cancer in postmenopausal women.[7]

Similarly, Douchi et al. demonstrated a significant association between obesity and increased endometrial thickness in a prospective study.[13]

Lukanova et al.Further concluded that increased endometrial cancer risk in postmenopausal women with high blood concentrations of androgens seems to be primarily due to their role as precursor hormones for estrogensynthesis.[14]

In our study, even among asymptomatic women, those classified as overweight or obese exhibited significantly higher estradiol levels compared to women with normal BMI. This finding suggests a potential subclinical risk for estrogen-sensitive conditions, which may precede overt clinical manifestations such as abnormal uterine bleeding or malignancy. It highlights the importance of BMI as a modifiable endocrine risk factor in postmenopausal health assessment and preventive care.

Strengths of this study include the use of a clearly defined, asymptomatic postmenopausal cohort and standardized methods for both estradiol estimation (ELISA) and BMI classification (WHO/ICMR criteria). However, some limitations must be acknowledged. The sample size was relatively small and derived from a single geographic region, limiting generalizability. Additionally, confounding variables such as diet, physical activity, insulin resistance, and other metabolic factors were not assessed in this study but may influence both BMI and hormone levels.

CONCLUSION

This study establishes a clear and statistically significant positive correlation between body mass index (BMI) and serum estradiol levels in asymptomatic postmenopausal women. As BMI increases, so does serum estradiol, primarily due to

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enhanced peripheral aromatization of androgens in adipose tissue and reduced levels of sex hormone-binding globulin (SHBG). These findings highlight the pivotal influence of adiposity in shaping the postmenopausal hormonal milieu, independent of overt clinical manifestations

Given the known association between elevated estradiol levels and estrogen-sensitive pathologies such as endometrial hyperplasia and carcinoma, obesity represents a modifiable endocrine risk factor with significant clinical relevance in postmenopausal health. The study highlights the need for early identification and monitoring of women at higher risk based on their BMI and hormonal profile.

Recommendations

1. **Routine Hormonal Screening:** Incorporate serum estradiol measurement as part of routine endocrine evaluation in overweight and obese postmenopausal women, even if asymptomatic.
2. **BMI Monitoring and Management:** Promote weight management programs tailored to postmenopausal women to reduce adiposity and the associated risk of estrogen-dependent disorders.
3. **Lifestyle Interventions:** Encourage regular physical activity and dietary modifications as primary strategies for lowering BMI and improving overall hormonal balance.
4. **Risk-Based Surveillance:** Initiate closer endometrial surveillance (e.g., periodic ultrasonography) in obese postmenopausal women, particularly those with high estradiol levels.
5. **Further Research:** Conduct larger, multicentric longitudinal studies to explore causality, evaluate long-term outcomes, and examine the impact of interventions on estradiol levels and endometrial pathology.

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