

## Comparison of Blood Pressure and Hormonal Changes During Various Phases of Menstrual Cycle in Normal Healthy Females of Reproductive Age Group

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### Abstract

*The menstrual cycle is characterized by cyclical hormonal variations that influence multiple physiological systems, including cardiovascular regulation. Fluctuations in estrogen and progesterone across different phases of the menstrual cycle may affect autonomic nervous system activity, vascular tone, and fluid balance, thereby influencing blood pressure. This study aimed to evaluate changes in systolic and diastolic blood pressure and correlate them with hormonal variations during the menstrual, follicular, ovulatory, and luteal phases in healthy females of reproductive age group. A comparative study was conducted on 90 healthy females volunteers aged 18–40 years with regular menstrual cycles. Blood pressure was measured using standardized sphygmomanometry, and serum estrogen and serum progesterone levels were estimated using ELISA during each phase of the cycle. Results showed that systolic and diastolic blood pressure were lowest during the follicular phase and highest during the luteal phase. Estrogen levels peaked during ovulation, while progesterone levels were highest during the luteal phase. A significant positive correlation was observed between progesterone levels and blood pressure during the luteal phase, while estrogen showed an inverse association with blood pressure in the follicular and ovulatory phases. The findings suggest that hormonal fluctuations during menstrual cycle significantly influence cardiovascular parameters and may contribute to phase-related symptoms such as premenstrual discomfort and migraine. Awareness of physiological blood pressure variations across menstrual phases may help in accurate clinical assessment and cardiovascular risk evaluation in women.*

**Keywords:** *Menstrual cycle; Blood pressure; Estrogen; Progesterone; Cardiovascular physiology; Reproductive age*

### Introduction

The menstrual cycle is a complex physiological process regulated by the hypothalamic–pituitary–ovarian axis and is characterized by periodic changes in ovarian hormones that prepare the female body for potential pregnancy [1,2]. A normal menstrual cycle lasts approximately 28 days and is divided into menstrual, follicular, ovulatory, and luteal phases, each associated with characteristic hormonal patterns primarily involving estradiol and

progesterone [1,8]. These hormones exert widespread effects not only on the reproductive system but also on cardiovascular, metabolic, and neuroendocrine functions [4,9]. Estradiol is known to have vasodilatory properties mediated through nitric oxide synthesis and improved endothelial function, while progesterone may exert variable effects on vascular tone, sodium retention, and fluid balance [10–13]. Blood pressure regulation is influenced by autonomic nervous system activity, renin–angiotensin–aldosterone system, plasma volume, and vascular reactivity, all of which may be modulated by ovarian hormones [3,12,14].

Several women report symptoms such as headache, dizziness, palpitations, and fatigue during specific phases of the menstrual cycle, suggesting underlying cardiovascular changes [6]. Understanding physiological blood pressure variation during menstrual phases is important for accurate diagnosis of hypertension and evaluation of cardiovascular risk in women [3,15]. Previous studies have reported inconsistent results, with some showing increased blood pressure during the luteal phase and others showing minimal variation across cycle phases [5,6]. Differences in methodology, sample size, hormonal estimation, and ethnic background may account for such discrepancies. Indian population-based data on this topic remain limited [6]. Hence, the present study was designed to assess phase-wise changes in blood pressure and correlate them with serum estradiol and progesterone levels in healthy reproductive-aged women.

## Materials and Methods

This comparative observational study was conducted in the Department of Physiology, Rama Medical College, Hospital and Research Centre, Kanpur, after obtaining approval from the Institutional Ethics Committee. A total of 90 healthy females volunteers aged 18–40 years with regular menstrual cycles (cycle length 26–32 days) were included in the study after obtaining informed written consent [1,2]. Participants were recruited from undergraduate and postgraduate students of the institution. Exclusion criteria included history of hypertension, diabetes mellitus, thyroid disorders, anemia, polycystic ovarian syndrome, irregular menstrual cycles, pregnancy, lactation, smoking, alcohol consumption, and use of hormonal contraceptives or any medications known to affect blood pressure or hormonal status [3,6].

Each participant was evaluated during three phases of the menstrual cycle: menstrual phase (day 0–5), proliferative phase (day 6–14), and secretory phase (day 15–28) [1,8]. Blood pressure was recorded using a calibrated aneroid sphygmomanometer in the sitting position after a rest period of at least 10 minutes. Measurements were taken from the right arm supported at heart level, and the average of two readings taken five minutes apart was considered for analysis. Systolic blood pressure was noted at the appearance of Korotkoff sounds (Phase I) and diastolic blood pressure at disappearance of sounds (Phase V), following standard physiological measurement guidelines [1,7].

Venous blood samples were collected under aseptic conditions during each phase of the menstrual cycle for estimation of serum estradiol and serum progesterone levels. Hormonal estimation was performed using the enzyme-linked immunosorbent assay (ELISA) method in the central laboratory following manufacturer's instructions and standard laboratory protocols [9,11]. All data were entered in Microsoft Excel and analyzed using SPSS software version 26. Results were expressed as mean  $\pm$  standard deviation (SD). Repeated Measures Analysis of Variance (RM-ANOVA) was applied to compare systolic blood pressure, diastolic blood pressure, serum estradiol, and serum progesterone levels across the three phases of the menstrual cycle, followed by post-hoc multiple comparison tests when overall significance was observed [5,12]. A p-value of less than 0.05 was considered statistically significant.

## Results

A total of 90 healthy females participants with regular menstrual cycles were included in the study. The mean systolic and diastolic blood pressure as well as serum estradiol and serum progesterone levels were analyzed across the menstrual, proliferative, and secretory phases of the menstrual cycle.

**Blood Pressure Parameters During Different Phases of Menstrual Cycle:** Table 1 shows the comparison of systolic and diastolic blood pressure during different phases of the menstrual cycle. The mean systolic blood pressure increased progressively from the menstrual phase ( $109.42 \pm 4.55$  mmHg) to the proliferative phase ( $115.78 \pm 4.05$  mmHg) and was highest during the secretory phase ( $118.13 \pm 4.70$  mmHg). Similarly, mean diastolic blood pressure was lowest during the menstrual phase ( $69.07 \pm 5.20$  mmHg), increased during the proliferative phase ( $76.62 \pm 3.43$  mmHg), and reached maximum during the secretory phase ( $79.22 \pm 1.85$  mmHg).

**Table 1. Blood Pressure Parameters During Different Phases of Menstrual Cycle (n = 90)**

Phase	Systolic BP (mmHg) Mean $\pm$ SD	Diastolic BP (mmHg) Mean $\pm$ SD
<b>Menstrual phase</b>	109.42 $\pm$ 4.55	69.07 $\pm$ 5.20
<b>Proliferative phase</b>	115.78 $\pm$ 4.05	76.62 $\pm$ 3.43
<b>Secretory phase</b>	118.13 $\pm$ 4.70	79.22 $\pm$ 1.85
Overall (RM-ANOVA)	<b>F = 64.2, p &lt; 0.001</b>	<b>F = 98.5, p &lt; 0.001</b>

**Post-hoc analysis:**

Menstrual < Proliferative (p < 0.001); Proliferative < Secretory (p = 0.003) — Systolic BP  
Menstrual < Proliferative (p < 0.001); Proliferative < Secretory (p = 0.001) — Diastolic BP

**Table 2. Serum Estradiol Levels During Different Phases of Menstrual Cycle (n = 90)**

Phase	Serum Estradiol (pg/ml) Mean $\pm$ SD
<b>Menstrual phase</b>	28.66 $\pm$ 5.47
<b>Proliferative phase</b>	84.33 $\pm$ 9.13
<b>Secretory phase</b>	106.46 $\pm$ 83.35
Overall (RM-ANOVA)	<b>F = 56.9, p &lt; 0.001</b>

**Post-hoc analysis:**

Menstrual < Proliferative (p < 0.001); Proliferative < Secretory (p = 0.01)

**Table 3. Serum Progesterone Levels During Different Phases of Menstrual Cycle (n = 90)**

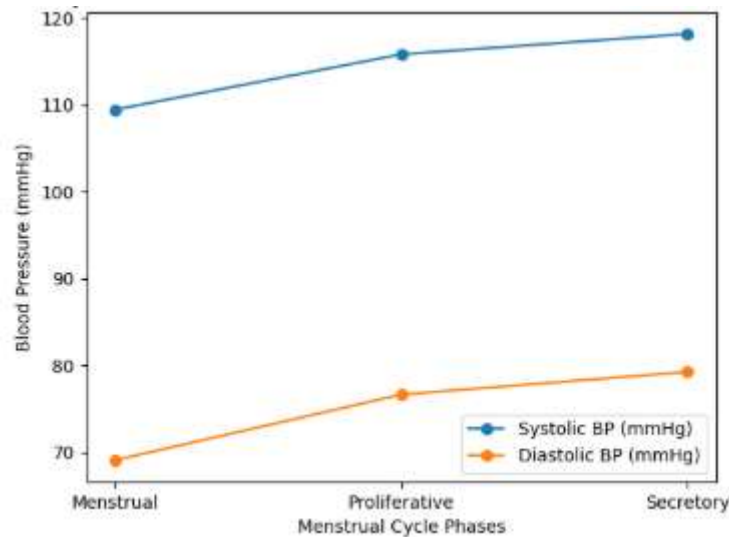
Phase	Serum Progesterone (ng/ml) Mean $\pm$ SD
<b>Menstrual phase</b>	2.02 $\pm$ 0.51
<b>Proliferative phase</b>	1.63 $\pm$ 0.73
<b>Secretory phase</b>	4.40 $\pm$ 5.22
Overall (RM-ANOVA)	<b>F = 41.3, p &lt; 0.001</b>

**Post-hoc analysis:**

Secretory > Menstrual (p < 0.001); Secretory > Proliferative (p < 0.001);  
Menstrual vs Proliferative (p = 0.12, Not Significant)

Repeated measures ANOVA showed a statistically significant difference in systolic blood pressure (F = 64.2, p < 0.001) and diastolic blood pressure (F = 98.5, p < 0.001) across the

three phases. Post-hoc analysis revealed that systolic and diastolic blood pressure were significantly higher in the proliferative phase compared to the menstrual phase ( $p < 0.001$ ), and further increased significantly in the secretory phase compared to the proliferative phase ( $p = 0.003$  for systolic BP and  $p = 0.001$  for diastolic BP)



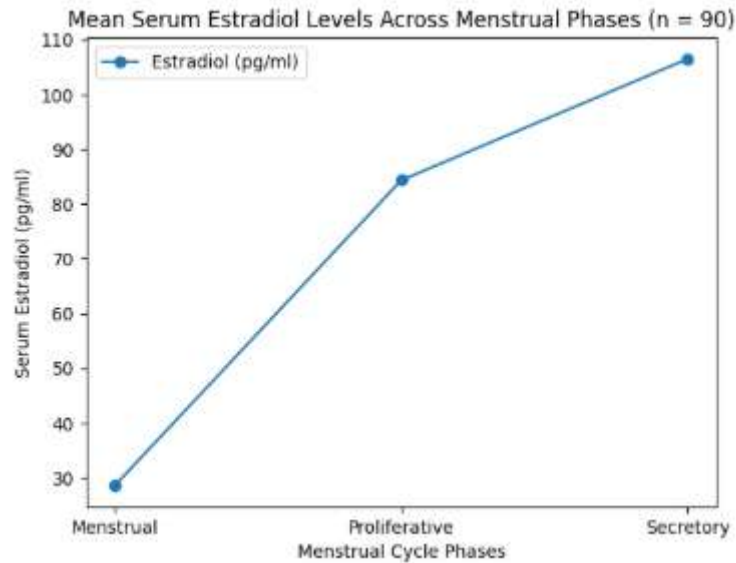
**Figure 1.** Mean systolic and diastolic blood pressure values across menstrual, proliferative, and secretory phases of the menstrual cycle among healthy females ( $n = 90$ ).

**Serum Estradiol Levels During Different Phases of Menstrual Cycle:** Table 2 depicts the variation in serum estradiol levels across menstrual cycle phases. The mean estradiol level was lowest during the menstrual phase ( $28.66 \pm 5.47$  pg/ml), increased significantly during the proliferative phase ( $84.33 \pm 9.13$  pg/ml), and reached the highest value during the secretory phase ( $106.46 \pm 83.35$  pg/ml).

Repeated measures ANOVA demonstrated a statistically significant difference in estradiol levels across the three phases ( $F = 56.9$ ,  $p < 0.001$ ). Post-hoc comparison showed a significant rise from menstrual to proliferative phase ( $p < 0.001$ ) and from proliferative to secretory phase ( $p = 0.01$ ) (Figure 2).

**Serum Progesterone Levels During Different Phases of Menstrual Cycle:** Table 3 presents the serum progesterone levels during different phases of the menstrual cycle. The mean progesterone level was  $2.02 \pm 0.51$  ng/ml during the menstrual phase and  $1.63 \pm 0.73$  ng/ml during the proliferative phase, with no statistically significant difference between these two phases ( $p = 0.12$ ). However, progesterone levels increased markedly during the secretory phase ( $4.40 \pm 5.22$  ng/ml).

Repeated measures ANOVA showed a statistically significant overall difference in progesterone levels across phases ( $F = 41.3$ ,  $p < 0.001$ ). Post-hoc analysis demonstrated that progesterone levels during the secretory phase were significantly higher compared to both menstrual and proliferative phases ( $p < 0.001$  for both comparisons), while the difference between menstrual and proliferative phases was not statistically significant (NS)



**Figure 2.** Mean serum estradiol levels across menstrual, proliferative, and secretory phases of the menstrual cycle among healthy females (n = 90).

## Conclusion

The study concludes that significant phase-wise variations in blood pressure occur during the menstrual cycle, with higher values observed during the luteal phase and lower values during the follicular phase. These variations are closely associated with changes in estrogen and progesterone levels. Awareness of physiological blood pressure fluctuations related to menstrual phases is important for accurate cardiovascular assessment in women of reproductive age and may have implications in management of premenstrual and cardiovascular symptoms.

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