Original Article

DOI: 10.7860/JCDR/2025/80740.21897

Physiology Section

Heart Rate, Blood Pressure, Rate Pressure Product in Young Healthy Females at Three Time Points of Menstrual Cycle: Associations with Cycle Length and Body Weight

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ABSTRACT

Introduction: The menstrual cycle exerts profound cyclical effects on the functioning of the reproductive and cardiovascular systems in health and disease. Cyclical changes in the cardiovascular system due to the menstrual cycle are less studied compared with those in the reproductive system. There exist significant lacunae and conflicting findings in the literature regarding the effect of the menstrual cycle on the cardiovascular system. Hence, this study investigated cyclical variations in cardiovascular parameters across the menstrual cycle.

Aim: To assess cardiovascular parameters across different menstrual phases and correlate them with cycle length and body weight in healthy young females.

Materials and Methods: A cross-sectional study was conducted in the Department of Physiology, Aarupadai Veedu Medical College and Hospital, Puducherry, India, from July 2018 to June 2024. A total of 73 regularly menstruating healthy females aged 18-24 years with cycle lengths of 21-35 days were included. Women with menstrual abnormalities, chronic illness, or those on any medications were excluded from the study. Heart Rate (HR), Blood Pressure (BP), and body weight were measured daily throughout the cycle at the same time of day. Three data points were collected: preovulatory, ovulatory, and postovulatory phases, at 21st, 14th, and 7th days preceding the last day of the cycle, respectively. Data were analysed using statistical tests appropriate for repeated measures. The Type I error was set at 0.05, and p-value<0.05 was considered statistically significant.

Results: The mean heart rate significantly differed (p-value<0.001) among the three days, with the highest values in the postovulatory phase. Differences were also observed in the Rate Pressure Product (RPP) with p-value=0.0254. Systolic Blood Pressures (SBP) and Diastolic Blood Pressures (DBP) significantly correlated with body weight in each phase (p-value<0.001).

Conclusion: Cardiovascular parameters varied across the menstrual phases and showed different correlations with cycle length and body weight. These findings may guide personalised drug therapy and lifestyle modifications.

Keywords: Body weight, Cardiovascular, Cycle length, Menstrual cycle

INTRODUCTION

Female sex hormones have a profound influence on the cardiovascular system. Under physiological conditions, secretions of oestrogen and progesterone vary across the phases of a regular menstrual cycle. Oestrogen begins to rise midway through the follicular phase and peaks just before ovulation; both oestrogen and progesterone are elevated during the mid-luteal (postovulatory) phase [1]. Different hormonal environments during the follicular and luteal phases may have implications for cardiovascular function.

Oestrogen has been regarded as cardioprotective by helping prevent hypertension during the reproductive years, supported by observations of salt-induced hypertension after ovariectomy [2]. Emerging evidence also suggests that oestrogen can have vasoconstrictive effects, which are reported in the literature [3]. This has been observed in women undergoing fertility treatments and in those using oestrogen-containing oral contraceptives [4,5]. Transdermal oestrogen has also been shown to cause endothelium-derived vasodilation [3]. Progesterone has a vasodilatory effect and has been shown to decrease vascular tone in humans and in animal studies [6]. However, the influence of female sex hormones on the cardiovascular system is less studied than their effects on the reproductive organs.

Heart rate is a major determinant of myocardial work and oxygen demand. It is determined by a complex interplay of reflexes, autonomic nervous system activity, and the hormonal milieu. Several studies have observed a HR lowering effect of oestrogen [7,8]. The literature is conflicting: some studies report increased heart rates in high-oestrogen states [9,10]; others report higher heart rates in the postovulatory phases [11-13]; and yet others find no significant differences between phases [14,15].

The SBP is largely determined by cardiac output, which depends on stroke volume and heart rate. DBP is determined by vascular tone, governed by the balance of various vasodilator and vasoconstrictor agents. Oestrogen and progesterone exert significant effects on vascular tone and reactivity, so BP parameters are expected to differ across the phases of the menstrual cycle [16]. There is disagreement in the literature regarding the state of blood pressure across the phases [16]. RPP is an index of myocardial work and is the product of SBP and HR (often divided by 100 in some contexts) [13]. It is important to observe RPP across the menstrual cycle, as both SBP and HR may vary across phases.

Menstrual cycle length has been associated with long-term morbidity and mortality in women. Some studies report that longer cycle lengths are associated with adverse outcomes and deranged cardiovascular parameters, while others report associations with shorter cycle lengths and cardiovascular disease [17,18]. Cross-sectional studies examining these associations in young, apparently healthy individuals are limited. Body weight is associated with long-term cardiovascular morbidity and mortality. Studies have observed associations between increased body weight and the menstrual cycle [19,20]. The literature is limited on the associations among body weight, cardiovascular parameters, and cycle length. Moreover, body weight changes are observed during the menstrual cycle [20], but the magnitude of weight change across cycle phases and its associations with cardiovascular parameters and cycle length are not well-established in the literature.

In this context, there exist significant gaps and conflicting findings exist in the literature regarding the effect of the menstrual cycle on cardiovascular parameters. Therefore, this study aimed to investigate the cyclical variations in cardiovascular parameters (HR, BP and RPP) at three points of the menstrual cycle in healthy young females. Also, the objectives were to measure and compare the cardiovascular parameters (HR, BP and RPP) in healthy young adult females at three phases of the menstrual cycle and to correlate the cardiovascular parameters with body weight and cycle length.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Physiology, Aarupadai Veedu Medical College and Hospital, Puducherry, India, from July 2018 to June 2024. Approval was obtained from the Institutional Research Committee (AVIRC2018026) and the Institutional Ethics Committee (AV/IEC/2018/042).

Inclusion criteria: Healthy, regularly menstruating females aged 18-24 years were included, as many cardiovascular parameters vary with age.

Exclusion criteria: Females with chronic illness, cardiovascular abnormalities, or menstrual disorders were excluded.

The sampling method was convenience sampling.

Sample size calculation: The study was designed with 80% power, α=0.05, and β=0.20. The expected difference in means for HR was three beats per minute with a standard deviation of nine beats per minute, as estimated by a pilot study [21]. The estimated sample size was 73.

Study Procedure

Interested volunteers were approached and enrolled in the study after obtaining written informed consent. A detailed medical history was recorded, and they underwent routine physiological examination. Participants were instructed to avoid caffeine and nicotine for 12 hours prior to testing. Measurements were taken daily between 8–9 a.m. in the Electrophysiology laboratory, Department of Physiology. Subjects were placed in a supine position for 10 minutes. After 10 minutes of rest, HR, SBP and DBP were recorded in duplicate. Measurements were taken at the same time of day for one complete menstrual cycle, using an Omron digital BP machine (HEM-8712). From SBP and DBP, Pulse Pressure (PP=SBP-DBP), Mean Arterial Pressure (MAP=DBP+1/3×PP), and RPP (RPP=SBP×HR×0.01) were calculated. Daily body weight was recorded using a digital scale to the nearest 0.1 kg [22].

The larger study recorded cardiovascular parameters on all days of one complete menstrual cycle in addition to other parameters. Data pertaining to cardiovascular parameters at three time points were presented here as preovulatory, ovulatory, and postovulatory phases. These correspond to the 21st, 14th, and 7th days preceding the last day of the menstrual cycle, respectively. The data were analysed retrospectively, as measurements had been recorded daily throughout the cycle. Although all participants had regular cycles, ovulation was not confirmed by imaging [23].

STATISTICAL ANALYSIS

Normality was assessed using the Kolmogorov-Smirnov test. Normally distributed data were expressed as mean±SD; non normal data as Median, Interquartile Range (IQR). For related groups, repeated-measures Analysis of Variance (ANOVA) was used for normal data and the Friedman test for non normal data. For unrelated groups with non normal data, the Kruskal-Wallis test was used. The null hypothesis was rejected at p-value<0.05. Analyses were performed using GraphPad Prism 3 and Statistical Package for Social Sciences 21.0.

RESULTS

Physiological ranges of values and their distributions are shown in [Table/Fig-1]. Body weight showed a normal distribution in all three phases of the menstrual cycle.

S. No.	Variables	Sample size	Mean±SD	Median, Interquartile	Passed normality
1	Age (in years)	73	19.191±0.659	19, (19 to 19)	No
2	Cycle duration (in days)	73	30.04±2.731	30, (28 to 32)	No
3	Ovulation day	73	16.04±2.731	16, (14 to 18)	No
4	Preovulatory weight (kg)	73	58.77±11.77	56.9, (50.5 to 67.25)	Yes
5.	Ovulatory weight (kg)	73	58.97±11.84	57.5, (51.55 to 67.3)	Yes
6	Postovulaory weight (kg)	73	58.74±11.72	57, (51.45 to 67.4)	Yes

[Table/Fig-1]: Descriptive data of cycle duration, ovulation day, preovulatory, ovulatory and postovulatory with respect to body weight of study subjects.

The physiological ranges and their distributions in the preovulatory phase are shown in [Table/Fig-2]. HR, SBP, and PP showed normal distributions.

S. No.	Variables	Sample size	Mean±SD	Median, Interquartile	Passed Normality
1	HR (beats per minute)	73	77.71±8.199	77.5, (72.5 to 82.25)	Yes
2	SBP (mmHg)	73	100.7±9.646	100, (94.5 to 105.5)	Yes
3	DBP (mmHg)	73	65.84±7.699	65.5, (61.75 to 68.75)	No
4	PP (mmHg)	73	34.85±4.698	35, (31.25 to 37.5)	Yes
5	MAP (mmHg)	73	77.46±8.101	76.67, (73.5 to 81)	No
6	RPP (mmHg)	73	78.44±12.42	75.99, (71.49 to 87.28)	No

[Table/Fig-2]: Descriptive data of Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Pulse pressure (PP), Mean Arterial Pressure (MAP) and Rate Pressure Product (RPP) of study subjects in preovulatory phase.

The physiological ranges and their distributions in the ovulatory phase are depicted in [Table/Fig-3]. Heart rate, DBP, PP, MAP, and RPP showed normal distributions.

S. No.	Variables	Sample size	Mean±SD	Median, Interquartile	Passed Normality
1		73	79.23±8.318	78.5, (74 to 85.25)	Yes
2	SBP (mmHg)	73	98.92±9.723	98.5, (94 to 103)	No
3	DBP (mmHg)	73	65.12±8.414	63.5, (60 to 70.75)	Yes
4	PP (mmHg)	73	33.81±5.556	33.5, (31 to 36.75)	Yes
5	MAP (mmHg)	73	76.39±8.477	75.67, (71.33 to 80.42)	Yes
6	RPP (mmHg)	73	78.51±11.99	77.96, (70.41 to 84.16)	Yes

[Table/Fig-3]: Descriptive data of study subjects in ovulatory phase.

The physiological ranges and their distributions in the postovulatory phase are shown in [Table/Fig-4]. HR, SBP, DBP, PP, and MAP showed normal distributions.

S. No.	Variables	Sample size	Mean±SD	Median, interquartile	Passed normality
1	HR (beats per minute)	73	82.18±9.105	82.5, (74 to 89.5)	Yes
2	SBP (mmHg)	73	100.9±11.4	101, (93.75 to 108.3)	Yes
3	DBP (mmHg)	73	65.54±9.049	65.5, (59 to 70.25)	Yes
4	PP (mmHg)	73	35.4±5.417	35, (31.75 to 39.5)	Yes
5	MAP (mmHg)	73	77.34±9.559	77.33, (71.25 to 81.75)	Yes
6	RPP (mmHg beats/min)	73	83.25±14.99	80.54, (74.27 to 92.38)	No

[Table/Fig-4]: Descriptive data of study subjects in postovulatory phase.

Significantly higher heart rate was seen in the postovulatory phase compared with the preovulatory and ovulatory phases (p-value<0.001). Similarly, RPP was also significantly higher in the postovulatory phase (p-value=0.0254). However, SBP, DBP, PP and MAP were not significantly associated with the phase of the menstrual cycle (p-value>0.05) [Table/Fig-5]. Test of significance: repeated measures ANOVA.

S. No.	Variable	Preovulatory (n=73)	Ovulatory (n=73)	Postovulatory (n=73)	p-value
1	HR (beats per minute)	77.71, 8.199	79.23, 8.318	82.18, 9.105	<0.001
2	SBP (mmHg)	100, (94.5 to 105.5)	98.5, (94 to 103)	101, (93.75 to 108.3)	0.1437
3	DBP (mmHg)	65.5, (61.75 to 68.75)	63.5, (60 to 70.75)	65.5, (59 to 70.25)	0.5992
4	PP (mmHg)	34.85; 4.698	33.81; 5.556	35.4; 5.417	0.0832
5	MAP (mmHg)	76.67, (73.5 to 81)	75.67, (71.33 to 80.42)	77.33, (71.25 to 81.75)	0.3235
6	RPP (mmHg beats/min)	75.99, (71.49 to 87.28)	77.96, (70.41 to 84.16)	80.54, (74.27 to 92.38)	0.0254

[Table/Fig-5]: Comparison of cardiovascular parameters between various phases of menstrual cycle
Test of Significance: Heart Rate & Pulse pressure: Repeated Measures ANOVA; Systolic, Diastolic, Mean arterial blood pressures and Rate Pressure Product: Friedman Test

Body weight differences between the phases of the menstrual cycle were not statistically significant (p-value=0.357) [Table/Fig-6]. Test of significance used was Kruskal-Wallis test.

S. No.	Variable	Preovulatory (n=73)	Ovulatory (n=73)	Postovulatory (n=73)	p-value
1	Body weight (kg/m^2)	58.77 11.77	58.97 11.84	58.74 11.72	0.3571 (F-value =0.9784)

[Table/Fig-6]: Comparison of body weight between various phases of menstrual cycle.
Test of significance: Repeated Measures ANOVA

Significantly higher variations were observed in HR, SBP, PP, and RPP between the various phases of the menstrual cycle (p-value<0.05). Such significance was not observed in DBP (p-value=0.0849) [Table/Fig-7]. Test of significance used was Spearman's correlation.

Preovulatory cardiovascular parameters (average) are labelled as Preovulatory Systolic BP (Pre_SBPA), Preovulatory DBP (Pre_DBPA), Preovulatory Heart Rate (Pre_HRA), Preovulatory PP (Pre_PPA), Preovulatory Mean Arterial BP (Pre_MAPA), Preovulatory RPP (Pre_RPPA), and Preovulatory body weight (Pre_Weight).

S. No	Variables	Sample size	Preovulatory and ovulatory	Ovulatory and postovulatory	Post and preovulatory	p-value
1	HR (beats per minute)	73	-2.5 (-8.25 to 4.5)	-1.5 (-7 to 3.25)	3.5 (-1.5 to 10.5)	<0.001
2	SBP (mmHg)	73	2 (-3 to 5.75)	-1.5 (-6.75 to 3.25)	0 (-5.5 to 4)	0.0138*
3	DBP (mmHg)	73	0.5 (-3.5 to 5.25)	-0.5 (-5.25 to 4.25)	-0.5 (-4 to 3)	0.2448
4	PP (mmHg)	73	0.5 (-3.5 to 4.75)	-1 (-5.75 to 1.75)	1 (-3 to 4.25)	0.0215
5	MAP (mmHg)	73	1.33 (-2.667 to 5.25)	-0.667 (-4.833 to 3.25)	0.1667 (-4.667 to 2.67)	0.0849
6	RPP (mmHg)	73	-1.22 (-8.98 to 7.88)	-2.72 (-12.485 to 3.78)	4.6 (-3.595 to 11.758)	<0.001

[Table/Fig-7]: Comparison of variations in cardiovascular parameters between the phases of menstrual cycle.
Test of Significance: Kruskal Wallis test

Preovulatory cardiovascular parameters positively correlated with body weight across the different phases of the menstrual cycle. No significant correlation was observed between heart rate and body weight in any phase of the menstrual cycle. Statistically significant correlations were observed between body weight and SBP, DBP, and MAP (p-value<0.05). RPP significantly correlated with body weight. No statistically significant correlation was observed between any of the preovulatory cardiovascular parameters and cycle length although an insignificant positive correlation was observed between heart rate and cycle duration [Table/Fig-8].

Statistically significant correlations were observed between various ovulatory cardiovascular parameters and body weight across the phases of the menstrual cycle. No significant correlation was observed between ovulatory heart rate and body weight in any phase of the cycle (p-value>0.05). Significant correlations were observed between body weight and SBP, DBP, and mean arterial blood pressure (p-value<0.001). No statistically significant correlation was observed between any of the ovulatory cardiovascular parameters and menstrual cycle length [Table/Fig-9].

Statistical significance in correlations was observed between body weight in each PP and MAP. No statistically significant correlation was observed between any of the ovulatory cardiovascular parameters and menstrual cycle length [Table/Fig-10].

Significant correlations were observed between variations in SBP, DBP, PP, and mean arterial pressure across the menstrual phases and body weight. In individuals with higher body weight, variations in cardiovascular parameters were greater between the phases of the menstrual cycle. Such observations were not observed for variations in heart rate with body weight. Variations in heart rate between the postovulatory and preovulatory phases showed a negative correlation with cycle length, though it was not statistically significant (p-value=0.066) [Table/Fig-11].

DISCUSSION

In current study, resting heart rate was significantly higher in the postovulatory phase of the menstrual cycle. This is in agreement with previous studies [11,12]. Similarly, the RPP was significantly higher in the postovulatory phase. The other cardiovascular parameters did not show statistical significance. In the present study, the luteal phase showed a significant rise in heart rate but was not accompanied by statistically significant changes in DBP or mean arterial pressure. Therefore, higher heart rates in the luteal phase may be non reflexive in origin and not due to a reflex rise from vasodilation, which might be expected due to the high progesterone levels in the luteal phase.

No significant changes in body weight were observed between the different phases of the menstrual cycle. This is in contrast to previous studies by Watson PE and Robinson MF and Kanellakis S et al., which reported a significant rise in body weight during the luteal phase that decreased in the menstrual phase [19,20]. Regarding variations in cardiovascular parameters across the phases of the menstrual cycle, significant differences were observed in HR, SBP, PP, and MAP. An increased heart rate and a decreasing trend in SBP, PP, and MAP were observed between the preovulatory and ovulatory phases. Previous studies by Moran VH et al., and Dunne FP et al., have shown changes in BP across the menstrual cycle [13,24]. However, no change was observed in DBP in the present

Parameters	Cycle Length		Preovulatory Weight		Ovulatory Weight		Postovulatory Weight	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Cycle Length	-	-	0.023	0.846	0.004	0.97	0.032	0.789
Pre_SBPA	-0.02	0.87	0.483	<0.001*	0.477	<0.001*	0.489	<0.001*
Pre_DBPA	0.071	0.552	0.422	<0.001*	0.42	<0.001*	0.429	<0.001*
Pre_HRA	0.19	0.107	0.065	0.585	0.054	0.649	0.083	0.487
Pre_PPA	-0.156	0.188	0.299	0.01*	0.292	0.012	0.301	0.01*
Pre_MAPA	0.037	0.756	0.459	<0.001*	0.456	<0.001*	0.466	<0.001*
Pre_RPPA	0.118	0.322	0.337	0.004*	0.327	0.005*	0.353	0.002*

[Table/Fig-8]: Spearman's Correlation with cycle length, body weight during preovulatory, ovulatory and postovulatory phases of menstrual cycle with preovulatory cardiovascular parameters.
Test of Significance: Spearman's Correlation; Pre_SBPA: Preovulatory systolic blood pressure (Average); Pre_DBPA: Preovulatory diastolic blood pressure (Average); Pre_HRA: Preovulatory heart rate (Average); Pre_PPA: Preovulatory pulse pressure (Average); Pre_MAPA: Preovulatory mean arterial blood pressure (Average); Pre_RPPA: Preovulatory rate pressure product (Average); Pre-Weight: Preovulatory body weight

Parameters	Cycle duration		Preovulatory weight		Ovulatory weight		Postovulatory weight	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
O_SBPA	-0.079	0.509	0.515	<0.001*	0.523	<0.001*	0.515	<0.001*
O_DBPA	0.028	0.815	0.418	<0.001*	0.407	<0.001*	0.424	<0.001*
O_HRA	0.148	0.211	-0.047	0.693	-0.078	0.514	-0.027	0.824
O_PPA	-0.18	0.128	0.267	0.022*	0.299	0.01*	0.259	0.027*
O_MAPA	-0.012	0.922	0.474	<0.001*	0.47	<0.001*	0.478	<0.001*
O_RRPA	0.067	0.573	0.303	0.009*	0.286	0.014*	0.318	0.006*

[Table/Fig-9]: Spearman's Correlation with cycle length, body weight during preovulatory, ovulatory and postovulatory phases of menstrual cycle with ovulatory phase cardiovascular parameters.
O_ SBPA: Ovulatory systolic blood pressure (Average); O_ DBPA: Preovulatory diastolic blood pressure (Average); O_HRA: Ovulatory heart rate (average); O_PPA: Ovulatory pulse pressure (average); O_MAPA: Ovulatory mean arterial blood pressure (average); O_RPPA: Ovulatory rate pressure product (average); O_Weight: Ovulatory body weight

Parameters	Cycle length		Preovulatory weight		Ovulatory weight		Postovulatory weight	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Post_SBPA	-0.125	0.293	0.601	<0.001*	0.59	<0.001*	0.604	<0.001*
Post_DBPA	-0.083	0.484	0.512	<0.001*	0.51	<0.001*	0.511	<0.001*
Post_PPA	-0.123	0.299	0.41	<0.001*	0.389	0.001*	0.416	<0.001*
Post__MAPA	-0.102	0.39	0.562	<0.001*	0.556	<0.001*	0.563	<0.001*
Post_HRA	-0.056	0.637	0.054	0.651	0.082	0.489	0.065	0.582
Post_RPPA	-0.114	0.335	0.411	<0.001*	0.42	<0.001*	0.42	<0.001*

[Table/Fig-10]: Spearman's Correlation with cycle length, body weight during preovulatory, ovulatory and postovulatory phases of menstrual cycle with ovulatory phase cardiovascular parameters.
Post_ SBPA: Postovulatory systolic blood pressure (Average); Post_ DBPA: Postovulatory diastolic blood pressure (Average); Post_HRA: Postovulatory Heart Rate (Average); Post_PPA: Postovulatory Pulse Pressure (Average); Post_MAPA: Postovulatory Mean arterial blood pressure (Average); Post_RPPA: Postovulatory Rate Pressure Product (Average); Post_Weight: Postovulatory body weight

Cardiovascular parameters	Cycle length		Preovulatory weight		Ovulatory weight		Postovulatory weight	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Delta_SBP_AB	0.075	0.527	-0.046	0.702	-0.063	0.595	-0.038	0.75
Delta_SBP_BC	0.083	0.484	-0.234	0.046	-0.207	0.079	-0.237	0.043*
Delta_SBP_CA	-0.161	0.174	0.287	0.014*	0.277	0.018*	0.282	0.015*
Delta_DBP_AB	0.056	0.636	-0.049	0.679	-0.035	0.767	-0.048	0.685
Delta_DBP_BC	0.132	0.264	-0.149	0.209	-0.159	0.18	-0.142	0.232
Delta_DBP_CA	-0.181	0.126	0.193	0.103	0.192	0.103	0.185	0.118
Delta_PP_AB	0.042	0.723	-0.012	0.917	-0.046	0.7	-0.004	0.974
Delta_PP_BC	-0.054	0.651	-0.12	0.313	-0.073	0.54	-0.132	0.265
Delta_PP_CA	0.011	0.926	0.138	0.244	0.125	0.292	0.142	0.231
Delta_MAP_AB	0.072	0.546	-0.053	0.654	-0.052	0.66	-0.049	0.679
Delta_MAP_BC	0.125	0.293	-0.193	0.102	-0.19	0.108	-0.189	0.109
Delta_MAP_CA	-0.188	0.111	0.244	0.038*	0.239	0.041*	0.236	0.044*
Delta_HRA_AB	0.033	0.78	0.094	0.427	0.111	0.348	0.092	0.439
Delta_HRA_BC	0.183	0.122	-0.092	0.438	-0.146	0.217	-0.086	0.472

Delta_HRA_CA	-0.216	0.066	-0.005	0.969	0.032	0.789	-0.009	0.942
Delta_RPPA_AB	-0.007	0.952	0.015	0.899	0.028	0.814	0.024	0.840
Delta_RPPA_BC	0.215	0.068	-0.180	0.127	-0.197	0.095	-0.187	0.112
Delta_RPPA_CA	-0.202	0.086	-0.154	0.194	0.187	0.114	0.156	0.188

[Table/Fig-11]: Spearman's Correlation with variations in cardiovascular parameters with cycle length, pre, ovulatory and postovulatory body weights.
A: Preovulatory phase; B: ovulatory phase; C: postovulatory phase; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PP: Pulse pressure; MAP: Mean arterial blood pressure; AB: Difference between A & B phase, BC: Difference between B & C phase, CA: Difference between C & A phase

study. Therefore, it can be concluded that the significant changes in cardiovascular parameters may be primarily due to changes in heart rate, among other factors.

Cycle length did not significantly correlate with preovulatory, ovulatory, and postovulatory body weights [Table/Fig-8]. Studies by Huang C et al., and Wang YX et al., have shown significant correlations between cycle length and cardiovascular parameters, indicating increased cardiovascular morbidity with longer menstrual cycle lengths. In the present study, significant positive correlations were observed between cardiovascular parameters and body weights in all phases of the menstrual cycle [17,25]. The magnitude of increases in SBP and mean arterial blood pressures in the luteal phase was positively correlated with body weight. This finding was statistically significant and suggests that higher rises in blood pressure parameters during the luteal phase occur in individuals with higher body weights. The magnitude of the heart rate rise in the luteal phase with cycle length was negatively correlated, though not statistically significant (p-value=0.066). Similar observations were seen for the RPP, though not statistically significant. These observations imply that the phases of the menstrual cycle exert a profound effect on cardiovascular functioning and must be considered in the management of cardiovascular diseases and conditions in women.

Limitation(s)

Ovulation was not confirmed with imaging techniques, which is a limitation of the study.

CONCLUSION(S)

Profound alterations in cardiovascular physiological variables were observed between the various phases of the menstrual cycle. However, changes in body weight were not significant between the phases. Both SBP and DBP significantly correlated with body weight in each phase. These findings may help in risk prediction, planning personalised medicine, and prescribing exercise for women.

Declaration: The study was presented at the Integrated International Conference on Exercise-Fitness to Therapy, ABP-icon2022, on 30 September 2022. However, the authors declare that there has been no publication of their presentation, including abstracts, in any journal.

Acknowledgement

The authors thank all the participants for their cooperation, without which the study would not have been possible.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 10, 2025
- Manual Googling: Aug 28, 2025
- iThenticate Software: Aug 30, 2025 (13%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: Jun 20, 2025
Date of Peer Review: Jul 21, 2025
Date of Acceptance: Sep 02, 2025
Date of Publishing: Oct 01, 2025