Evaluation of Blood Pressure and Heart Rate Variability during Different Phases of Menstrual Cycle

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Every month, between puberty and menopause, a woman's body goes through a number of changes to get it ready for a possible pregnancy. This series of hormone-driven events is called the menstrual cycle. A woman's menstrual cycle is divided into three phases - proliferative phase, secretory phase and menstrual phase. The hormonal surge during each phase causes profound effects on the cardiovascular system as well. However, previous research reported conflicting results in this concept. Thus the controversial statements associating blood pressure and heart rate variability with menstrual cycle promoted this research.

Objective: The aim of this study is to evaluate the blood pressure and heart rate variability during different phases of the menstrual cycle.

Materials and Methods: 20 healthy women belonging to the proliferative, secretory and menstrual phase of the menstrual cycle were analyzed for autonomic functions tests using systolic blood pressure, diastolic blood pressure, pulse rate and heart rate variability.

Results: It showed that there was a statistically significant increase in systolic blood pressure, diastolic blood pressure, and pulse rate during the secretory phase. There was an increase in heart rate variability during the menstrual phase but this was statistically insignificant.

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Conclusion: The study concluded that there were significant changes in blood pressure during the secretory phase and pulse rate and insignificant increase in heart rate variability during the menstrual phase. Thus, the study also concluded that sympathetic nervous activity in the secretory phase is significantly greater than in the proliferative phase, whereas parasympathetic nervous activity is predominant in the proliferative phase.

Keywords: Hormones; autonomic nervous system; proliferative; secretory; menstrual phase.

1. INTRODUCTION

The reproductive system of women shows regular cyclic changes. It lasts for an average of 28 days and contains 2 types of cycles - ovarian and endometrial [1]. Ovarian cycles have follicular phase and luteal phase whereas endometrial cycle has proliferative, secretory and menstruation. Analysis of heart rate variability is a useful tool to assess cardiac autonomic control and the rhythm is controlled by the sino-atrial node [2][3]. Endogenous sex hormones change constantly during menstrual cycle. Estrogen increases halfway through the follicular phase whereas both estrogen and progesterone are elevated during the mid-luteal phase [4]. In women, heart rate variability is related to many factors including endogenous sex hormones, menstrual cycle, menopause, hormone replacement therapy, body mass index and physical conditioning [5]. However it is not confirmed whether in the general population, low heart rate variability is a consequence of disease or an indicator of an underlying mechanism for future disease[6][7]. Our team has extensive knowledge and research experience that has translate into high quality publications[8–12].

Several of the researches done before had conflicting results. Vishrutha et al noticed a higher sympathetic control during the proliferative phase of menstrual cycle [13] Brar et al concluded a higher parasympathetic control during the proliferative phase of the menstrual cycle [2],[14]. From a physiological point of view, the overall heart rate variability expresses the general capacity of the cardiovascular system to respond to physiological regulations as well as external demands that modulate the heart rate[15-17].

One of the most important reasons for carrying out this research is, although a lot of people have looked into this, their results have always been conflicting [18]. Thus, to have a clearer picture, this study is being carried out. Moreover, it can explain the symptoms of premenstrual syndrome, improves quality of life. It can make women aware of their cardiovascular problems and helps to take precautionary measures during the menstrual phase [19]. Thus, the aim of the study is to evaluate the autonomic functions or cardiovascular status during different phases of the menstrual cycle [20]. The null hypothesis is that there is not much of a heart rate variation during the menstrual cycle and the assumed hypothesis is that there is heart rate variation during menstrual cycle [21].

2. MATERIALS AND METHODS

Normal young and healthy female students, 20 in number, with anthropometrically matched variables were chosen for this study, from Saveetha Dental College and Hospitals, Poonamallee, Chennai. The Institutional human ethical committee has given ethical clearance for the present study as it does not involve invasive procedures. After explaining the experimental procedure and making the subjects fully aware of their role in the project, informed consent was obtained from them. Those with a history of irregular menstrual cycles, hypertension, diabetes mellitus, cardio-respiratory disorders, practicing yoga or any respiratory exercises were excluded from the study.

The students were assessed under three different conditions- proliferative, secretory, menstrual phase. The students were assessed for systolic blood pressure, diastolic blood pressure, pulse pressure, mean arterial pressure, pulse rate, heart rate variability.

Systolic blood pressure (SBP), Diastolic blood pressure (DBP) was recorded using a sphygmomanometer. Pulse pressure (PP) was noted as the difference between SBP and DBP. Mean arterial pressure was noted using the formula DBP+⅓xPP. The pulse rate was noted for 1 minute. The Heart rate variability was recorded continuously in Lead II by using an ECG machine (VESTA 301i electrocardiograph) in lying posture (10 waves), while getting up and after standing (60 waves). HRV was calculated as a 30:15 ratio, i.e. the longest RR interval in the 30th heartbeat divided by the shortest RR
interval in the 15th heartbeat after standing. And then, differences and variations were analyzed.

2.1 Statistical Analysis

Data were entered in an Excel spreadsheet and were analyzed using descriptive analysis and one way ANOVA. SPSS version 23 was used to carry out the test. Independent variables include age, gender, profession, educational and socioeconomic status and dependent variables include dietary habits and types of communities.

3. RESULTS

Table 1. The table below represents the different parameters and the respective mean ± standard deviation values of the different phases in the menstrual cycle

| Parameters                 | Proliferative phase | Secretory Phase | Menstrual Phase |
|----------------------------|---------------------|-----------------|-----------------|
| Systolic Blood pressure    | 103 ± 5             | 117 ± 6.6 *     | 100 ± 7         |
| Diastolic Blood pressure   | 77 ± 6.2            | 83 ± 4.7 *      | 67.7 ± 8.3      |
| Pulse rate                 | 68 ± 4.3            | 75 ± 8.4 *      | 70 ± 0.8        |
| Pulse pressure             | 32 ± 6.2            | 32 ± 4.4        | 33 ± 5          |
| Mean arterial pressure     | 106 ± 5             | 108 ± 6 *       | 105 ± 5.2       |
| Heart rate variability     | 1.08 ± 0.0          | 1.07 ± 0.0      | 1.09 ± 0.0      |

The values are expressed as mean ± standard deviation. The asterisk represents statistical significance p < 0.05 in the secretory phase when compared to the proliferative and menstrual phase.

Fig. 1. The above bar graph represents the comparison of systolic blood pressure during the three phases of the menstrual cycle. The X axis denotes systolic blood pressure and the Y axis depicts its value. It is observed that there is increased change in systolic blood pressure in the secretory phase when compared to the proliferative phase and menstrual phase with p-value significant at p= 0.000 (p<0.05)

Fig. 2. The above bar graph represents the comparison of diastolic blood pressure during the three phases of the menstrual cycle. The X axis denotes diastolic blood pressure and the Y axis depicts its value. It is observed that there is increased change in diastolic blood pressure in the secretory phase when compared to the proliferative phase and menstrual phase with p-value significant at p= 0.04 (p<0.05)
Fig. 3. The above bar graph represents the comparison of pulse pressure during the three phases of the menstrual cycle. The X axis denotes pulse pressure and the Y axis depicts its value. It is observed that there is increased change in pulse pressure in the menstrual phase when compared to the proliferative phase and secretory phase with p-value insignificant at \( p=0.925 \) (\( p<0.05 \)).

Fig. 4. The above bar graph represents the comparison of mean arterial pressure during the three phases of menstrual cycle. The X axis denotes mean arterial pressure and the Y axis depicts its value. It is observed that there is increased change in diastolic blood pressure in the secretory phase when compared to the proliferative phase and menstrual phase with p-value significant at \( p=0.13 \) (\( p<0.05 \)).

Fig. 5. The bar graph represents the comparison of pulse rate during the three phases of menstrual cycle. The X axis denotes pulse rate and the Y axis depicts its value. It is observed that there is increased change in pulse rate in the secretory phase when compared to the proliferative phase and menstrual phase with p-value significant at \( p=0.03 \) (\( p<0.05 \)).
Fig. 6. The above bar graph represents the comparison of heart rate variability during the three phases of menstrual cycle. The X axis denotes heart rate variability and the Y axis depicts its value. It is observed that there is increased change in heart rate variability in the menstrual phase when compared to the proliferative phase and menstrual phase with p-value insignificant at p= 0.895 (p<0.05)

4. DISCUSSION

Researchers have made significant proof showing the association between the influence of female sex hormones and autonomic functional status of heart[22][23]. Autonomic functional status is an important evaluation in the pathogenesis of many cardiovascular conditions like hypertension, myocardial ischemia and cardiac arrhythmias[1,24]. Neurons containing nuclear estrogen receptor (ER) and Membrane binding sites for estrogen, progesterone and testosterone have been identified in brain centers involved in the regulation of cardiovascular functions [25]. Previous reports also suggested that Estrogen receptor β gene expression predominates in human vascular smooth muscle cells (VSMCs) [26].

Also reports suggested that in women, endogenous female sex hormones, like estrogens, are cardioprotective in nature [27]. They act via multiple mechanisms like increased high-density lipoprotein, decreased low-density lipoprotein, and increased release of vasodilators such as nitric oxide (NO) and prostacyclin (PGI₂) from vessel walls and inhibition of vascular constriction and lowering of blood pressure and decreased platelet aggregation. This might be the cause of changes in blood pressure, heart rate during different phases of menstrual cycle[28][29].

Differences in the autonomic system among genders may be attributed to the differences in afferent receptor stimulation, central reflex transmission and the efferent pathways in post synaptic signalling [30]. Also there were many differences in the size or number of neurons, variations in receptors, neurotransmitter content and metabolism as well [31]. It has also been postulated that alterations in sex hormones can cause cardiovascular abnormalities and ultimately lead to atherosclerotic Cardiovascular disease [32].

Heart rate variability in systolic blood pressure is high in the secretory phase according to the results of this study and this falls in line with another research finding that states that significant increase in systolic blood pressure during onset of maturation [33]. However, there is a decrease in morning systolic blood pressure in the luteal phase. Overall, the morning diastolic blood pressure is less and there is a decrease in systolic blood pressure in the luteal phase [34]. There is an increase in the morning systolic and diastolic blood pressure at the onset of menstruation. The fact that systolic blood pressure increases during the luteal phase is not confirmed [35].

Similarly there is increased sympathetic modulation and decreased parasympathetic modulation in the luteal phase. No significant changes were found on vagal modulation for follicular and luteal phases [36]. Studies carried out by [37][2] and[38], showed an increased sympathetic activity in the secretory phase, similar to the findings of this study.

However, there is significant increase in the sympathetic activity in the luteal phase in studies conducted by [39] and[40]. Also, there was
increased parasympathetic modulation in the luteal phase in a study done by [41].

4.1 Future Scope of the Study

The future scope involves more research in the area of study using further tests on autonomic functions and this research would help in improving the quality of life of women and would help them in taking few precautions around the time of menstruation in case they have any health issues. More research would also allow us to establish relations among the different aspects of health, leading to increased improvement in healthcare.

5. CONCLUSION

Thus, the present study concluded that sympathetic nervous activity in the secretory phase is greater than in the proliferative phase, whereas parasympathetic nervous activity is predominant in the proliferative phase.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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