National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

A comparative analysis of cardiovascular response to stress in menstrual and follicular phase in medical students

Surendra S Wadikar, Gaurang G Bhandarkar

Department of Physiology, Topiwala National Medical College and B. Y. L. Nair Charitable Hospital, Mumbai, Maharashtra, India

Correspondence to: Surendra S Wadikar, E-mail: surenin18@yahoo.com

Received: April 22, 2017; **Accepted:** May 11, 2017

ABSTRACT

Background: Autonomic function tests based on cardiovascular responses to stressors are simple and non-invasive methods to help the clinician to make a proper assessment of the state of autonomic nervous system so as to determine an appropriate line of treatment for patients considering the impact of hormonal changes in females during menstrual cycle. **Aims and Objectives:** To study cardiovascular response to stress in menstrual and follicular phases of menstrual cycle and to analyze the impact of menstrual phase on cardiovascular response to stress. **Materials and Methods:** The study was conducted at Topiwala National Medical College, Mumbai on 30 normal healthy females between the age group of 18 and 26 years in menstrual and follicular phases with 24-32 days menstrual cycle. The tests performed were: Deep breathing test (expiration: inspiration [E:I] index), orthostatic tolerance test (postural index), Valsalva maneuver, isometric handgrip test (IHG), and cold pressor test (CPT). **Results:** Paired *t*-test was used for analysis. Values were expressed as a mean ± standard deviation. E:I index, postural index and Valsalva ratio were greater in follicular phase than in menstrual phase ($P < 0.05$). Rise in systolic and diastolic blood pressure due to IHG and CPT was greater in menstrual phase than in follicular phase ($P < 0.05$). **Conclusion:** Results indicated that there was increased cardiovascular response to stress during menstrual phase as compared to follicular phase.

KEY WORDS: Expiration:Inspiration Index; Postural Index; Isometric Hand Grip; Stress; Valsalva Ratio

INTRODUCTION

Various physical, psychological, and behavioral changes are experienced by women during menstrual cycle. The menstrual cycle has three phases, namely, menstrual phase, follicular phase, and luteal phase. These phases are regulated by interplay of various hormones released from anterior pituitary and ovary.[1]

Access this article online

Website: www.njppp.com

Quick Response code

DOI: 10.5455/njppp.2017.7.0515211052017

Indian women experience various kinds of stresses in their daily life. Menstrual phase of the cycle poses additional stress besides the other environmental stressors. Autonomic function tests based on cardiovascular responses to stressors give objective results and are simple and non-invasive tests, which help the clinician to make a proper assessment of the state of autonomic nervous system that helps to determine what effects various stressful procedures and / or drugs will have on female patients.[1,2]

MATERIALS AND METHODS

Study Population

The study was conducted at Topiwala National Medical College, Mumbai on 30 normal healthy female subjects in the age group of 18-26 years in menstrual and follicular phases with 24-32 days menstrual cycle. The subjects were selected randomly by simple random sampling according to the statistical principle of normal distribution. Females were assessed on the 3rd and 10th day of the menstrual cycle.

Females in secretory phase of their cycle, having irregular menstrual cycles, oligomenorrhea, menorrhagia, as well as females on oral contraceptive pills, females with habits of smoking, tobacco chewing, alcohol consumption, and who were diagnosed cases of diabetes mellitus, thyroid disorders, asthma were excluded from the study.[2,3]

All subjects were explained in detail in the language understood by them and to their satisfaction about the procedure of the tests to be conducted on them. Voluntary written informed consent was taken from all the subjects. The tests were conducted on female subjects in secluded room with curtains and in the presence of female attendant in Physiology Department lab. The data were kept confidential.

The study was approved by Institutional Ethics Committee of Topiwala National Medical College and B.Y.L. Nair Charitable Hospital, Mumbai.

Materials

The following materials were used:

1. Sphygmomanometer
2. Stethoscope
3. Electrocardiogram (ECG) machine with limb leads, ECG strips, ECG jelly, and gauze
4. Student physiograph
5. Trough with water at 4°C
6. Hand grip dynamometer.

Methods

Tests for autonomic functions:

The following tests were carried out in this study to assess autonomic nervous system:

1. Deep breathing test
2. Orthostatic tolerance test
3. Valsalva maneuvre
4. Isometric handgrip (IHG) test
5. Cold pressor test (CPT).

Deep breathing test[4]

The subject was asked to lie down in supine position for 15 min. The heart rate and respiration monitoring were done from the ECG and student physiograph recordings, respectively. A baseline recording of ECG and respiration was taken for 30 seconds. The subject was asked to take slow and deep inspiration followed by slow and deep expiration such that each breathing cycle lasted for 10 seconds. Calculation was done from the tracing of respiration and ECG. The changes in the heart rate between inspiration and expiration were averaged over 6 cycles. R-R interval increased during expiration and decreased during inspiration. The ratio of R-R interval during expiration versus inspiration is expiration:inspiration (E:I) index.

E:I index[4] = Maximum R-R interval during expiration/ Minimum R-R interval during inspiration

Orthostatic tolerance test[4]

The blood pressure and the ECG were recorded in supine position. The subject was instructed to attain standing posture in 3 seconds. The ECG was continuously recorded during the procedure. The blood pressure was measured at 1st and 5th min. 30:15 ratio was calculated from ECG. It is the ratio of R-R interval at 30th beat and R-R interval at 15th beat. The fall in systolic blood pressure was calculated.

Calculation: 30:15 ratio (postural index).

When a normal subject is made to stand up from lying down position, there is a characteristic immediate shortening of R-R interval that is maximal shortening around the 15th beat (tachycardia) after standing followed by relative lengthening that reaches a maximum limit around the 30th beat (bradycardia) after standing thus giving 30:15 ratio.

30:15 ratio[5,6] = Maximum R-R interval at 30th beat after standing/Minimum R-R interval at 15th beat after standing.

Valsalva maneuver[4]

This procedure was done in sitting position. The patient was instructed to blow into a mouthpiece attached to the sphygmomanometer. The subject had to maintain expiratory pressure at 40 mm Hg for 15 seconds. At the end of 15 seconds, the subject was asked to release the pressure. Valsalva ratio was calculated from the following formula.

Valsalva ratio[5,6] = Maximum R-R interval after the procedure/ Shortest R-R interval during the procedure

IHG test[7]

The baseline systolic and diastolic blood pressure values were recorded at rest. The subjects were asked to perform maximal voluntary contraction (MVC) by gripping the handgrip dynamometer, as hard as possible for few seconds and the maximum force exerted was noted down. After giving rest for a few minutes, the subjects were made to perform isometric exercise at 30% of MVC till occurrence of fatigue. Systolic and diastolic blood pressure recordings were taken at intervals of each minute during the period of exercise. The mean systolic and diastolic blood pressure, the increase in systolic and diastolic blood pressure during the isometric exercise was calculated and the maximal values of systolic and diastolic BP achieved during exercise was noted down.

CPT[7]

The hand of the subject was immersed up to the wrist in cold water at a temperature of 4°C for 1 min. Blood pressure was recorded at 30 seconds and 1 min of submersion of the hand. After taking out the hand, blood pressure was recorded after every minute, till it returned to the baseline. The increase in blood pressure from the baseline value (average of two values) to a maximal value, known as the range or response was obtained. The maximal systolic and diastolic values of blood pressure achieved at any time during the test, designated as the ceiling values were also noted.

RESULTS

Paired *t*-test was used for analysis. Values were expressed as a mean ± standard deviation. Table 1 shows values of E:I index. Table 2 shows the values of 30:15 ratio (postural index), and Tables 3, shows the values of Valsalva ratio. From the mentioned Tables 1, 2 and 3, it is evident that E:I index, postural index, and Valsalva ratio were greater in follicular phase than in menstrual phase ($P < 0.05$).

Table 4 shows values of the rise in systolic blood pressure and diastolic blood pressure due to IHG, which were greater in menstrual phase than in follicular phase ($P < 0.05$). Similarly, Table 5 shows values of rise in systolic blood pressure and diastolic blood pressure in response to CPT, which were greater in menstrual phase than in follicular phase ($P < 0.05$).

Table 1: Deep breathing test (E:I index)

Value	Menstrual phase	Follicular phase	Significance
Mean±SD	1.26±0.13	1.36±0.13	<0.05

SD: Standard deviation, E:I: Expiration:inspiration

Table 2: Orthostatic tolerance test (30:15 ratio/postural index)

Value	Menstrual phase	Follicular phase	Significance
Mean±SD	1.20±0.12	1.24±0.11	<0.05

SD: Standard deviation

Table 3: Valsalva maneuver (Valsalva ratio)

Value	Menstrual phase	Follicular phase	Significance
Mean±SD	1.19±0.10	1.29±0.11	<0.05

SD: Standard deviation

Table 4: IHG

Value	Menstrual phase	Follicular phase	Significance
Rise in systolic blood pressure Mean±SD	3.33±1.32	2.30±1.37	<0.05
Rise in diastolic blood pressure Mean±SD	2.73±1.11	1.60±0.93	<0.05

SD: Standard deviation, IHG: Isometric hand grip

Table 5: Cold pressor test (CPT)

Value	Menstrual phase	Follicular phase	Significance
Rise in systolic blood pressure Mean±SD	3.1±1.12	2.67±1.54	<0.05
Rise in diastolic blood pressure Mean±SD	2.33±1.45	1.77±1.01	<0.05

SD: Standard deviation, CPT: Cold pressor test

DISCUSSION

As per the above results, the tests measuring parasympathetic function, namely, E:I index, postural index (30:15 ratio), and Valsalva ratio showed higher values during follicular phase as compared to menstrual phase. Whereas, the tests measuring sympathetic function, namely, rise in systolic and diastolic blood pressures due to IHG test and CPT test showed higher values during menstrual phase as compared to follicular phase. This indicates that autonomic balance during follicular phase was shifted to parasympathetic dominance possibly because estrogen enhances vagal activity during follicular phase of the cycle.[8] Whereas, during menstrual phase, it was shifted to sympathetic dominance possibly due to fall in estrogen levels in this phase.

In daily life, the psychological and biological correlates of responsivity of cardiovascular system to environmental stressors experienced by females are mediated by balance between sympathetic and parasympathetic system.[9] Cardiovascular system reacts to this stress as a result of increased output and decreased reuptake of catecholamines by sympathetic part of autonomic nervous system.[2] This is supplemented by the fact that during menstruating phase, the level of estrogen hormone falls and levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) rise. As a result, there is increased sympathetic and low parasympathetic activity on exposure to stressors.[10]

During menstruating phase of the cycle, there is a lack of vagal activity enhancement as result of lack of estrogen, and it is postulated that there may be increased influence of raised levels of FSH and LH on cardiovascular system.[11] As a result, autonomic balance possibly shifts toward a sympathetic system and is responsible for increased cardiovascular responses to stress during menstrual phase as compared to follicular phase of the cycle.[12]

As a result, there is increased sympathetic activity on exposure to stressors like menstrual bleeding during menstrual phase. This shift of autonomic balance may be responsible for variable physical, behavioral, and psychological symptoms during menstrual phase of the cycle.[13]

Strengths and Limitations

To assess the effect of menstrual and follicular phase on cardiovascular response to stress a battery of stress tests was given to the subjects. Since the observations and results were not based on any single test and since the results showed uniform behavior and were statistically significant, the possibility of false positive results by chance was largely eliminated. However, there were limitations too; as all the tests employed were indirect indices of autonomic function. Besides, the possibility of other environmental stressors influencing results cannot be ruled out.

CONCLUSION

The results of this study indicate that menstrual stress affects cardiovascular function. The findings are consistent with most previous studies and further support the notion that autonomic balance shifts to sympathetic dominance during menstrual phase due to increased sympathetic activity during this phase as compared to follicular phase probably due to lack of estrogen.

ACKNOWLEDGMENT

We are thankful to the staff of Department of Physiology of Topiwala National Medical College and B. Y. L. Nair Charitable Hospital for helping us in conducting this study smoothly.

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How to cite this article: Wadikar SS, Bhandarkar GG. A comparative analysis of cardiovascular response to stress in menstrual and follicular phase in medical students. Natl J Physiol Pharm Pharmacol 2017;7(10):1041-1044.

Source of Support: Nil, **Conflict of Interest:** None declared.